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GENERAL SCIENCE QUARTERLY

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Published four times a year: in November, January, March and May
By W. G. WHITMAN, SALEM, MASS.
O. E. UNDERHILL, Editor, pro-tem
Entered as second class matter Nov. 6, 1916, at Salem, Mass., under the Act of March 3, 1879

$1.50 a year
40c a copy

NOVEMBER, 1925

VOLUME 10
NUMBER 1

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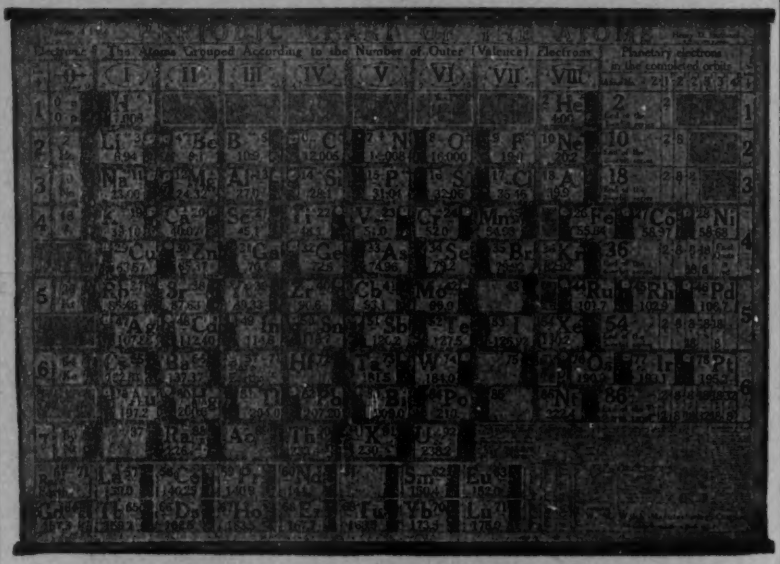

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General Science Quarterly
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Vol. X NOVEMBER 1925 No. 1

A Study of Achievement and Subject Matter in General Science

By AUGUST DVORAK.
School of Education, University of Washington.

CHAPTER I.

INTRODUCTION.

In 1864, when Fisher[1] attempted to establish some standards by which the achievements of school children in different elementary school subjects could be measured objectively, he started a new era in scientific school administration. The public, however, was not ready to receive Fisher's suggestions, so for approximately forty years nothing was done toward their fulfillment. Later, in 1894, when Rice[2] startled even the more progressive schoolmen with his facts regarding the insignificance of such factors as: (a) the amount of time, (b) the social status of the school or of the pupil, and (c) the time of day at which the subject was taught, as related to the success of the pupil in a given subject, the work of Fisher gained impetus. During the twenty-five years following Rice's monumental work, the American elementary and secondary schools have been the ground for many standardization, measurement, and curriculum studies.

Today the status of the subject matter of elementary and secondary school subjects varies anywhere from the practically established state of Latin, recent upheavals not to the contrary, to the most experimental state found in some of the vocational subjects. Standards in subject matter range anywhere from the rather well established four fundamentals in arithmetic to the rather subjective standards used in General

1 "See Jr. of Ed. Psy., vol. 4, p. 551. A quotation from The Museum, a Quarterly Magazine of Education, Literature, and Science, vol. III, 1864, is reproduced as a communication."—Thorndike.

2 Rice, J. M. "The Futility of the Spelling Grind." The Forum: 23:163-172; pp. 409-419, 1897.

Science. Methods of measurement of achievement in the various subjects range anywhere from the scientifically established test and scales, as in spelling and reading, to practically none at all, as in manual training and civics.

In spelling, for instance, we have the work of Ayres, Thorndike, Buckingham and others, all of whom have attempted not only to ascertain what words in the English language are most necessary in the average adult's vocabulary, but also to ascertain which of those necessary words the school children of different ages are capable of mastering. That information, once scientifically established, can be made the basis of selection of subject matter for each school grade, of method of presentation of subject matter, and of measurement of achievement in the subject. Such studies would serve to show what words can be most economically and usefully taught in different school years, and what words the child will master in the natural course of events as the result of other similar words previously mastered. They would also serve to show the relation of achievement in subject matter to abilities, either special or general, and to other subjects simultaneously or previously pursued. It is clear that a study of this kind thoroughly and completely carried out in any school subject, once that school subject itself is located in the school curriculum both as to time and place, would serve to secure maximum achievement and maximum usefulness with a minimum of effort.

The subject of "General Science" is a comparatively recent addition to the secondary school curriculum, and as a result of its comparative youth is as yet unstandardized and undefined both as to subject matter and achievement. In spite of its newness and the generalized nature of its contents, however, General Science has aroused a volume of popular interest sufficient, not only to warrant its place among the secondary school subjects, but also to place it among the required subjects in numbers of secondary schools. Consequently, to the writer—himself a teacher of General Science and keenly aware of the lack of standards and the lack of information regarding the relative values of different elements in the subject—a scientific analysis of the subject matter of General Science seems distinctly worth while.

CHAPTER II.

PURPOSE.

In general, the purpose of this study is, first,, the development of a measure of achievement in General Science in order to asecertain the relative amount of General Science subject matter possessed by school children, both that which is acquired specifically through instruction in General Science or in other science courses. And second, once this measure of achievement is secured, it is the purpose of this study to discover the amount of information acquired and retained by pupils, and to discover what factors limit and modify the acquisition and retention of General Science subject matter.

More specifically, the purpose of this study has been differentiated as follows:

(1) To ascertain to what extent the material supposedly taught in the General Science course is already possessed by pupils before taking the course. It has been the experience of the writer, that pupils in a given section, purposely selected for its homogeneity of ability, came to the class at the beginning of the year with various amounts of the subject matter already in their possession. In other words, certain portions of the generalized subject matter of General Science appears to be common knowledge.

(2) For this reason, a diagnostic test, which will serve to place pupils into sections homogeneous as to the point at which their General Science course should begin and as to what it should include, is to be developed.

(3) To find out to what extent the subject matter of General Science has been mastered sufficiently by pupils, who have had General Science, to enable them to state it objectively.

(4) To ascertain how much of the material once mastered is retained one year, two years and three years later.

(5) To study the differences between boys and girls, both as to the common knowledge of, and as to the acquisition of the subject matter of General Science.

(6) To investigate the relative difficulty of different items of the subject matter of General Science for boys and for girls. This is important, in order to determine whether there is any real difference in difficulty which would justify the popular bedief that General Science is easier for boys, or

that some parts of General Science are best mastered by boys.

(7) To compare achievement in General Science for different school grades, as determined by General Science test scores. The comparisons in General Science achievement of eighth grade pupils and of ninth grade pupils would be especially desired by Junior High School advocates.

(8) To ascertain what General Science information is acquired by pupils who do not take General Science. For this purpose control groups of pupils, who had not taken General Science, were used.

CHAPTER III.

SURVEY OF LITERATURE ON GENERAL SCIENCE.

A. HISTORY OF GENERAL SCIENCE.

The teaching of Chemistry as a college subject began in the United States as early as 1767 at Columbia College. As a secondary school subject, Chemistry made its debut in 1819 at Hassam Private Academy, North Carolina.[1] Since then, other sciences have appeared in the secondary school curricula. These sciences, in the main, tended towards such high specialization that about half a century later there began to be felt a need for a kind of science teaching which did not have as its goal specialization in science, but which did fill an immediate and perhaps even a local need.

Such a "reform" course was offered in 1869 by Thomas H. Huxley,[2] who gave a series of illustrated lectures to London children at the Royal Institution, and later published the course in a book entitled "Physiography." In this course Huxley dealt with the immediate vicinity of London and the Thames. His subject matter embodied the physiography and geology of the Thames basin and the activities of the London people. The course was informational and scarcely suited for the pupils of Edinburgh or Boston, but it filled a desired end.

It is interesting to note that Huxley gave as his aims of the introductory science course much the same objective as are outlined today for General Science. To quote:

---

1 Powers, S. R. "A history of the teaching of Chemistry in the secondary schools of the United States previous to 1850." Research Publications of the University of Minnesota, No. 13, p. 16.

2 Twiss, G. R. "A textbook in the principles of science teaching." The Macmillan Co., N. Y., 1921, pp. 411-435.

1. To furnish in the first year of high school the information and the training in thinking that are fundamental to the special sciences and are necessary to the successful pursuit of these sciences later on in high school or college.

2. To impart information from the scientific standpoint about the useful and interesting things that are all about us, especially for the benefit of those who will not go on to college and may not go farther in high school, and who, therefore, would otherwise remain ignorant of scientific facts and of the scientific way of dealing with the materials and forces that are everywhere available for our use.

3. . . . One writer regrets the failure of the schools to produce the crop of amateur scientists which is essential for keeping alive the popular interest in science so necessary to scientific progress in the nation. It would seem to be a worthy aim of a general science course to stimulate and foster such amateur interest in science.

4. . . . He is free to organize these materials with reference to these interests and these needs and to make voluntary problem-solving and purposeful information-getting the proximate aim of the pupils. He may thus hope to train the youngsters in methodically gathering information and applying systematic thought to the things in the environment that they desire to comprehend and manage.

5. It is thought by some that a general science course may serve to show something of the relations of the sciences to one another, of the order and unity that exist in nature, and of the essential unity of the scientific method, and thus that it may appeal to the imagination, contribute to a state of mental poise or balance, and perhaps develop some power of interpretation that could not so well be gained by separate courses in the special sciences. (Pp. 415-417.)[3]

From 1869 to the present, especially since 1900, an elaboration of Huxley's "Physiography" has been widely taught under the name of General Science. Few of these courses,[4] according to Twiss, surpass that of Huxley in organization and general local merit, because there are few "Huxleys" to teach them. From about 1912 to date, however, there have been many serious attempts to outline objectives for General Science which would satisfy the long-felt need of a science course in high school which did not aim at developing Edisons, but rather at teaching youthful citizens how to make use of Edison's work. Typical of writers in this vein are Barber,[5] Eikenberry,[6] Hessler,[7] and Downing.[8]

3 Twiss, G. R. Ibid.

4 Twiss, G. R. Ibid.

5 Barber, F. D. "Fundamental considerations in the reorganization of High School science." School Review, 24:724-734, 1916.

6 Eikenberry, W. L. "Facts about the General Science situation." School Review, 23:181-191, 1915.

7 Hessler, J. C. "General Science in the first year." School Science and Mathematics, Vol. XVI, pp. 407-411, 1916.

8 Downing, E. R. "What standard tests in science should do." School Science and Mathematics, Vol. XIX, pp. 651-654, 1919.

B. OBJECTIVES OF GENERAL SCIENCE.

Because there have been few "Huxleys" to teach and to organize the courses, General Science has undergone numerous experimental changes, most of which have been for the better. At the time courses of study and textbooks vary widely. In a recent study Webb[9] found that on classifying the subject matter of eighteen of the most commonly used textbooks of General Science that the two hundred six topics or items thus secured could be divided among eight basic secondary school sciences as follows:

Subject	*No. of Topics*	*Subject*	*No. of Topics*
Physics	56	Chemistry	33
Physiography	22	Domestic Science	13
Botany	22	Astronomy	10
Zoology	17	Miscellaneous	9
Physiology	24		

Because of the wide range of subject-matter which might be included in a course of General Science, there has been a growing feeling among science teachers that fairly concrete and definite objectives, which could be used as guides for limiting or extending the work in General Science, ought to be formulated. Therefore, at the instigation of the Science Section of the North Central Association of Science and Mathematics Teachers, Miss Philipine Crecelius prepared a report on the objectives of General Science.[10] Miss Crecelius sent out a questionnaire formulated by S. R. Powers, and from the returns was able to evaluate opinions of about 100 science teachers regarding the relative importance of 14 possible objectives of General Science. These objectives are given below in the order of the values assigned:

1. To provide opportunity for acquaintance with such elementary laws of nature as are necessary for the health of the individual and the community.

2. To give children information about those appliances which science has developed and which are useful in making

9 Webb, H. A. "General Science instruction in the grades." George McQuiddy Printing Co., Nashville, Tenn., 1921.

Webb, H. A. "Quantitative analysis of General Science." School Science and Mathematics, Vol. XVII, pp. 534-45, 1917.

10 Crecelius, Philippine. "A report on objectives of General Science teaching." School Science and Mathematics, Vol. 23:313-319, 1923.

for greater comfort and convenience in the home and community.

3. To provide opportunity for acquaintance with the simpler applications of science in public utilities, in order that the individual may more adequately fulfill the duties of citizenship.

4. To provide opportunity for acquaintance with the elementary laws of nature which aid in understanding those citizenship problems which arise in connection with such topics as conservation of our natural resources, smoke elimination, etc.

5. To contribute such specific ideals, habits and concepts as those of accuracy, persistence, open-mindedness, honesty, cause and effect, which are essential to the study of science.

6. To give pupils a broad and genuine appreciation of what the development of science means in modern social, industrial and national life.

7. To provide opportunity for the student to explore the fields of science for the purpose of educational and vocational guidance.

8. To satisfy the natural interests in the things and forces of nature with which men are surrounded and with which they must deal; to give information interesting purely for its own sake.

9. To develop system, order, neatness, and possibly other attributes to the end that they will function in the ordinary affairs of life.

10. To afford, in some measure, an opportunity to show the importance of scientific research and to stimulate the spirit of investigation and invention on part of students.

11. To make pupils able to read more intelligently and with greater interest, articles on science in magazines and scientific books of a popular character, and to read with greater understanding literature containing scientific allusions.

12. To correct common superstitions and ignorant practices.

13. To give children a full opportunity to indulge in the playful manipulation of toys, tools, machines, etc., in order that they may explore the world of reality as deeply and as widely as possible.

14. To give such training as will result in increasing respect for the work of recognized experts.

It may be worth while to note that while these objectives were not available when this study was begun, the writer used a somewhat similar set of objectives in the construction of the original test and final Scale Forms for the measurement of achievement in General Science. The writer tried to make each item satisfy one or more of the cardinal principles of Education,[11] namely:

1. Health.
2. Worthy use of leisure.
3. Vocation.
4. Citizenship.
5. Worthy home membership.
6. Command of fundamental processes.
7. Ethical character.

Recognition of the value of properly selected principles and facts of science for immediate, everyday use, has led to the development of courses in "Nature Study" for the elementary grades. Some of these courses in "Nature Study" are adapted for pupils as far down as the first and second grades. With the motto, "Study Nature First: Then Books about Her," Miss Conover,[12] of the Detroit City Schools, has organized a "Nature Study" course for pupils in the first and second grades. This course of study is well worth the attention of General Science teachers, as well as of first and second grade teachers. It is an excellent illustration of what can be accomplished in the construction of a course of study around specific objectives.

C. ACHIEVEMENT TESTS IN GENERAL SCIENCE.

In the interval between the work of Rice and the present time, a time which has been characterized in education by the development of tentative standards of achievement in school subjects and of tentative measuring devices for measuring the achievement of these standards, men in the field of secondary school science have contributed, or attempted to contribute,

11 "Cardinal Principles of Secondary Education." U. S. Bureau of Education Bulletin, 1918, No. 35.

12 Conover, Laura. "Course in Nature Study." Board of Education, Detroit Public Schools. 1922.

to the current test movement. To be sure, the preliminary attempts were handicapped by the same conditions which characterized the preliminary attempts at measurement in the other subjects, that is, lack of consideration of the many factors involved in the development of a statistically accurate measuring instrument. They were also handicapped by the fact that teachers of science in colleges and secondary schools were trained more or less only in the field of the specialized science which they taught. A Physics teacher was trained in Physics and a Chemistry teacher was trained in Chemistry. Usually neither of them had any training in educational practices and technique. This has frequently resulted, as stated under "History of General Science" in this chapter, in a desire on the part of the teacher to emphasize the teaching of the specialized subject, Chemistry or Physics, as a preparatory course for pupils all of whom were assumed to be beginning a prolonged and specialized course of training in that science achievements have not endured the effects of analytical knowledge that *a very limited per cent of pupils taking a science course in the high school continue their work in science even to the extent of taking an additional course in college, much less becoming specialists in that particular field.* Because of this condition, some of the attempts made to measure science achievements have not endured the effects of analytical educational criticism.

For instance, in a recent article by Dr. Foley[13], of the University of Indiana, is a severe criticism of the achievement of high school pupils in Physics. Dr. Foley bases his criticism on a ten item test which he gave to about 700 students entering the university and who presented high school credit in Physics. Dr. Foley's work is open to criticism itself, because he says nothing about the difficulty of the ten items, and their bearing on a high school course is not evaluated. Dr. Foley does not state whether or not students who have taken his *University course* in Physics would, one or two years later, do any better on his test than did the high school pupils who took it under his direction, one, two, and often several years after taking their high school course.

13 Foley, Arthur L. "The College student's knowledge of high school Physics." School Science and Mathematics, Vol. 12, No. 7, pp. 601-613.

In the field of Physics at least four other tests besides Dr. Foley's may be mentioned. Daniel Starch[14] prepared a test of Physics consisting of 75 questions, problems and incomplete statements, differentiated among mechanics, heat, light, sound, magnetism and electricity. On the basis of a comparatively small number of pupils he then prepared standard scores in each of the differentiated aspects of Physics. This test of achievement in Physics is open to two main criticisms, namely: (a) all the items are given equal value, and (b) the standard scores were secured on too few cases.

J. Crosby Chapman[15] prepared a test of Physics in electricity, magnetism, sound, and light, which consisted of 30 questions which were answerable by one word which the pupil was to write in. Criticism of this is that thirty words, the answers to the thirty questions, in the four fields of Physics mentioned, are a very small number of samples by which a pupil's achievement should be judged. The test was standardized by giving it to 158 high school pupils just finishing the study of Physics. As the author states: "This is meager evidence as to the suitability of this type of test, but, from a large amount of evidence obtained when engaged in army work, the author is convinced that *tests of this kind are well worth while* (words underlined by writer) when employed for the limited purpose for which they are designed."

The Randall, Chapman and Sutton "High School Physics Test"[16] consists of 14 problems, with spaces for the pupils to put the answers.

Franklin T. Jones[17] worked out a preliminary set of tests in Physics ("Union Science Tests for Practice and Comparison"). These consist of twenty-eight individual tests of five to ten problems or questions each, under different headings, such as: "thermometers," "heat," "work," "light A," light B." Each of these 28 tests could be better characterized as Chapter

14 Starch, Daniel. "Educational Measurements." Macmillan Co., N. Y., 1916.

15 Chapman, J. C. "The measurement of Physics information." School Review 27:748-49, Dec., 1919. Also J. C. Chapman (now deceased), Yale University, New Haven, Conn. Also D. P. Randall, Western Reserve University, Cleveland, Ohio.

16 Randall, Chapman, and Sutton. "The place of the numerical problem in high school Physics." School Review, 26:39-43. Jan. 1918.

17 Jones, F. T. "Practice exercises in Physics and chemistry." School Review, 26:341-48. May, 1918.

Test, to be given at the completion of each of the subjects mentioned. These tests, if properly evaluated, would be of much help to teachers.

Harold L. Camp,[18] of the University of Iowa, produced in 1921 some "scales for measuring results of Physics teaching." This work, a doctor's thesis, is very well worked out with one exception,—that in many times as few as sixty cases, in no case more than one hundred forty-nine cases, were used to secure standards.

L. L. Thurstone[19] also has prepared a test in Physics for college freshmen and high school seniors, which consists of twenty-five short problems.

H. W. Tilton[20], of the University of Pittsburgh, lists the Tilton Physics Tests for grades eleven and twelve, as also does J. Monroe Hughes,[21] of the University of Minnesota.

A somewhat new departure in the field of measurement of achievement in secondary school science has come from the efforts of Earl R. Glenn[22 23] and his assistants in the field of Physics and Chemistry. Instead of striving for a simple standardized test or several parallel tests of equal difficulty for measuring pupils' achievements at the *end* of any particular period of instruction, Glenn and his helpers have developed two series of tests, each test of the series covering a particular part of the subject matter of Chemistry or Physics. Instead of waiting until the end of the semester, term, or year, to give each test, each test is intended to be given whenever the particular part of the subject matter is covered during the course. There, therefore, is a standardized test to be given as part of the daily, weekly or monthly examination and review. The tests are comprehensive and long enough to measure

18 Camp, H. L. "Scales for measuring results of Physics teaching." Univ. of Iowa Studies in Education, Vol. II, No. 2, p. 50. Also Iowa Physics Test (Camp), Public School Publishing Co., Bloomington, Ill.

19 Thurstone, L. L. "Test V. Physics." Carnegie Institute of Technology, Pittsburgh. Also World Book Co., Chicago, Ill.

20 Tilton, Harry W. "Tilton Physics Tests," University of Pittsburgh, Pittsburgh, Penn.

21 Hughes, J. Monroe. University of Minnesota College of Education, Minneapolis, Minnesota.

22 Glenn, Earl R. "New Type Tests in Physics," Lincoln School, Teachers' College, Columbia University, N. Y.

23 Glenn, Earl R. "New Type Tests in Chemistry," Lincoln School, Teachers' College, Columbia University, N. Y.

the achievement of all pupils on each phase of the subjects as these phases are finished.

In Chemistry there are, besides the Glenn test, at least seven other tests for measuring students' achievement. J. Carlton Bell[24] has prepared a Chemistry test of 24 brief questions and one problem. Jones[25] has a Chemistry test (Union Science Series) which is of similar nature to his Physics test mentioned above.

Hanor A. Webb's test in Chemistry[26] consists of a series of names of Elements, Mixtures and Compounds. The pupil's problem is to label these names, "E," "M," or "C," as he judges them to be Elements, Mixtures or Compounds. Tentative norms have been worked out.

B. J. Rivett's Chemistry test[27] consists of: (a) 31 elements, the problem being to label them with the proper symbols; (b) a list of the 20 elements, the problem being to give their valence and 20 of their compounds with their formulae; and (c) 20 formulae, the problem being to give the names of the compounds for which they stand and state whether the compound is an acid, base or salt.

The General Chemistry test by Henry L. Gerry[28] follows a somewhat more scientific procedure. This test was recently put on the market with norms and standards well developed.

The Rich Chemistry Test[29] for High School Pupils, in two parts, seems to be well developed and sound in principle.

S. R. Powers'[30] Chemistry test, now completed, is one of the most elaborate and most scientific of all the science tests now being presented. It was constructed with consideration

24 Bell, J. C. "Study of the attainments of high school pupils in first year Chemistry." School Science and Mathematics, 18:425-432, May, 1918. Also Jr. Educational Psychology, Vol. IX, April, 1918.

25 Jones, F. T. Ibid.

26 Webb, H. A. "A preliminary test in Chemistry." Jr. of Ed. Psy., 10:36-43, January, 1919; also now procurable at H. A. Webb, George Peabody College, Nashville, Tenn.

27 Rivett, B. J. "Testing results in Chemistry." School Science and Mathematics, 19:742-745, Nov. 1919; also B. J. Rivett, Northwestern High School, Detroit, Mich.

28 Gerry, H. L. "Trial Test in General Chemistry," Graduate School of Education, Harvard University; now ready, Harvard Publication Bureau, Cambridge, Mass.

29 "Rich's Chemistry Test for High School Pupils," Public School Publishing Co., Bloomington, Ill.

30 Powers, S. R. "Chemistry Test," (World Book Co.) University of Minnesota.

of the objectives of Chemistry, the items are evaluated, and the scale is standardized with preliminary norms, now available, based on 1200 pupils.

A test in Biology by Leo M. Cossman,[31] consists of a list of words which the pupil was asked to define, and of spaces where the pupil was asked to make drawings of a typical "insect," a typical "flower," etc. There was no way of scoring the test objectively. A later form, the Ruch-Cossman Biology test,[32] is well constructed. The criticisms of the earlier form no longer apply.

N. M. Grier[33] has prepared an achievement test in Physiology, Botany and Zoology, each of which consists of 100 words of technical nature pertinent to those subjects. Pupils' instructions are:

1. Place a D before the terms you can define as exactly as words are ordinarily defined in the dictionary.
2. Place an E before the terms you can explain to one not familiar with their meaning.
3. Place an F before the terms with which you are roughly familiar.
4. Place an N before the terms which are new to you.
5. At the bottom write out the definitions of the first five words you marked D, and the first five you marked E.
6. Count the number of D's, E's, F's and N's, and record the result at the top of the page in the one-inch space.

F. T. Ullrich[34] has a similar test in Agriculture. The main objections to the tests by Grier and Ullrich are the difficulty of properly scoring them and the fact that the person evaluating a paper cannot know, by a study of five samples of dictionary definitions, whether a "D" means that the pupil putting down a "D" really knows the dictionary definition or not. Furthermore, there is a question whether dictionary definitions are really what one is trying to teach in a science subject.

Glenn and Powers[35] were experimenting with a General Science test which will be discussed in the chapter on "Method."

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31 Cossman, L. M. "Biology," University of Oregon.

32 Ruch-Cossman Biology Test for High Schools, World Book Co., Chicago, Ill.

33 Grier, N. M. "Range of information test in Biology." Jr. of Ed. Psy. 9:210-16, 388-93. April-September, 1918.

34 Ullrich, F. T. "Tests in agriculture." State Normal Schools, Platteville, Wisconsin.

35 Earl R. Glenn, Teachers' College, Columbia University; Samuel R. Powers, University of Minnesota, Minneapolis, Minn.

G. M. Ruch,[36] after experimenting with a similar test in General Science, finally evolved the Ruch-Popenoe "General Science Test,"[37] a very commendable test, consisting of 50 miltiple answer statements of General Science facts and 20 lettered diagrams. Concerning these diagrams are a number of completion statements which the pupil is asked to complete with the proper diagram letter.

There are also the Caldwell[38] Science Tests, Barber's[39] Standardized Tests, Downing's[40] Information Test in Science, and Herring's[41] test in Scientific Thinking.

With the exception of the tests by Powers, Ruch, Camp, Ruch-Cossman, Thurstone, and Glenn, the tests for secondary school science measurement, mentioned in the preceding paragraphs, have not developed beyond the preliminary steps of test construction. They are not, however, without value. They represent attempts in the scientific measurement of classroom products by men in the field of secondary school sciences. The writer has surveyed all this literature carefully and is indebted to the authors for valuable suggestions regarding procedure and for a few of the items actually used in his General Science Test. To Ruch he is especially indebted.

CHAPTER IV.

METHOD.

One of the first essentials in this study was to build up a preliminary measuring instrument of subject matter in General Science. Since economy of time, accuracy, and objec-

36 Ruch, G. M. "A range of information test in General Science." General Science Quarterly 4:257-62. Nov. 1919.

Ruch, G. M. "Range of information test in General Science; preliminary data on standards." Gen. Sci. Quarterly 5:15-19. Nov. 1920.

Ruch, G. M. "A new test in General Science," General Science Quarterly 7:188-197. March, 1923.

Ruche-Popenoe "General Science Test," World Book Company, Chicago, Ill.

37 Ruch-Popenoe "General Science Test," World Book Company, Chicago, Ill.

38 Caldwell, O. W. "The Gary Public Schools: Science Teaching," The General Education Board, N. Y. 1919.

39 Barber, A. B. "Barber's Standardized Science Tests," Clayton, New Mexico.

40 Downing, E. R. "A range of information tests in science," School Science and Mathematics 19:228-83. March, 1919. Also E. R. Downing, University of Chicago, Chicago, Ill.

41 Herring, J. P. "Measurements in Scientific Thinking." Jr. of Educational Psychology 9:535-58. December, 1919.

tivity were considered valuable characteristics of this measuring device, the following criteria were considered in the construction of the preliminary test:

(a) The material selected should cover the field.
(b) The material should range from easy to difficult.
(c) The arrangement of the test should be such as to facilitate readibility on the part of the pupils.
(d) The arrangement should be such as to facilitate accuracy in scoring.
(e) The items of the test should be definite and clear.
(f) There should be only one acceptable response to each item.
(g) The test should be given to as wide a range of pupils as possible, in order to test its selective power.

For the purpose of developing such a measuring instrument, the writer procured two unfinished studies begun simultaneously, the one by Earl R. Glenn, Lincoln School, New York, and the other by Samuel R. Powers, University of Minnesota. These studies represented a partial compilation of General Science material in the form of objective answer statements, problems, and science vocabulary. To these the writer added material in the same subject matter which was pertinent but which was not included in the above compilations. This additional material was gleaned from various kinds of preliminary attempts in General Science measurement (see Chapter III), from a survey of General Science textbooks. The resultant total number of individual items amounted to about six hundred. Out of this total were selected three hundred items which seemed to be most definately related to the subject, most objective in nature, and most justifiable in terms of the cardinal principles of education.[1]

These three hundred items were then reduced to the multiple answer type of statements. The list of three hundred statements, when completed, was reviewed by two science teachers at the University High School, University of Minnesota, who agreed that the choice of the three hundred items was inclusive and well differentiated among the different kinds of subject matter which go to make up General Science. Inasmuch as the list of three hundred items was to be revised and worked

1 Cardinal Principles of Secondary Education. U. S. Bureau of Education Bulletin, 1918, No. 35.

over later on the basis of pupil achievement, it was deemed satisfactory when it passed the combined judgments of three University High School science teachers.

The three hundred items were arranged in as random an order as possible. No one knew the order of difficulty of the different items. For each item the number of multiple answers was five. As will be shown later, this number of possible answers reduced successful guessing to a neglible amount.

A few of the 300 items of the original test are submitted here to illustrate the kinds of items of information used and the method of presentation:

DIRECTIONS.—Below are statements of scientific facts which are stated thus: "A fly is an ANIMAL, A FISH, AN INSECT, A REPTILE, A BUILDING." Of course a fly cannot be all the things which are printed in extra-black type. A fly is an insect; so if you underline "AN INSECT," that will show that you know which is correct. In the statement, "The heart pumps BLOOD, WATER, OIL, AIR, SAND," "BLOOD" should be underlined. Underline the correct word in the statements below, so that each statement is true. If you don't know, guess.

1. The normal temperature of a human being is 100 F., 104 F., 98.6 F., 93 F., 90F.....1
2. The souring of milk is caused by BACTERIA, HEAT, FREEZING AIR, MOISTURE 2
3. Ventilation is for the purpose of securing SUNLIGHT, WARMTH, PURE AIR, COMFORT, GERMS....3
17. The unit for measuring gas flow is the GALLON, WATT, CUBIC CENTIMETER, CUBIC FOOT, CUBIC YARD 17
54. When air is heated, it CONTRACTS, EXPANDS, FALLS, LIQUIFIES, SOLIDIFIES.....54
64. The temperature at which pure water boils is affected by the HEIGHT OF THE FLAME, THE AMOUNT OF WATER, THE AIR PRESSURE, THE DENSITY OF THE WATER, THE DEPTH OF THE WATER 64
122. Why are we quarantined for the Measles? TO PROTECT THE PATIENT, TO PREVENT THE SPREAD OF THE DISEASE, TO SATISFY PUBLIC OPINION, TO MAKE MONEY, TO KEEP THE PATIENT AT HOME.....122
142. The kidneys DIGEST FOOD, CLEAN BLOOD OF WASTES, BUILD UP NEW BLOOD CELLS, SUPPORT THE BACKBONE, ARE USELESS.....142

159. The centrifugal force of a cream separator separates milk from cream because the cream is LIGHTER, HEAVIER, THICKER, DENSER, GREASIER..159

180. The process of food manufacture in green plants is called RESPIRATION, MITOSIS, POLLINATION, PHOTOSYNTHESIS, PASTEURIZATION....180

196. A great bird student in our country was ROOSEVELT, BURROUGHS, DARWIN, EDISON, LONGFELLOW 196

216. Mosquitoes lay eggs ON SALT WATER, STAGNANT WATER, FRESH WATER, ON THE GROUND, IN GARBAGE 216

221. House flies lay their eggs IN WOOD, ON THE WATER, IN ANIMAL AND VEGETABLE WASTE, IN NESTS, IN THE SAND.....221

241. The cheapest food on the basis of calorific value is WHEAT FLOUR, BUTTER, MEAT, MILK, CELERY 241

252. Distance measured above sea level is called LONGITUDE, ALTITUDE, DECLINATION, INCLINATION, LATITUDE 252

260. Erosion can be prevented by BUILDING, IRRIGATION, PLANTING FORESTS, CUTTING DOWN FORESTS, MAKING DITCHES.....260

262. Ice cracks rock because IT IS COLD, WATER EXPANDS WHEN IT FREEZES, IT MELTS WHEN IT GETS WARM, IT IS HEAVY, IT IS BRITTLE 262

276. One of the three most required elements of the soil required for the growing of crops is OXYGEN, NITROGEN, SODIUM, CARBON, HYDROGEN.....276

283. The device in water or steam pipes for stopping the flow at any point is called A DAMPER, A FAUCET, VALVE, SWITCH, STOKER 283

300. A device for automatically regulating furnace fire is called A THERMOMETER, A THERMOSTAT, A BAROMETER, A GALVANOMETER, A DRAFT 300

The General Science test of three hundred items and a list of instructionsfor the person giving the test were sent out to principals or superintendents of twenty-two school systems with whom arrangements for the giving of the tests had pre-

viously been made by personal letter. The list of instructions was mimeographed, but the test was printed in order to facilitate accuracy and speed on the part of the pupils and accuracy and speed in scoring. The schools selected to give the test represented large, medium and small school systems of Minnesota. All pupils in the 8th, 9th, 10th, 11th and 12th grades of the twenty-two school systems, with the exception of the three largest school systems, were given the test, provided they happened to be present at the particular hour on the day when the test was presented. The total number of pupils who took the test approximated eleven thousand. In each of the three largest school systems the 8th grades of two most representative grade schools and all the pupils in one hibh school were given the test. All tests were taken by the pupils between the first and tenth of June, 1922. Table I shows numbers of returns of the test in terms of schools and grades.

TABLE I.

Total Number of Returns of General Science Test from Twenty-two Schools.

SCHOOL SYSTEM	GRADES					
	8th	9th	10th	11th	12th	Total
Annandale	25	33	18	26	9	111
Alexandria	41	97	78	84	75	355
Crookston	80	87	74	50	46	337
Duluth	96	220	400	313	237	1266
Excelsior	29	44	25	14	17	129
Ely	109	105	63	62	57	396
Fertile	25	38	22	23	9	117
Glencoe	35	25	34	20	23	137
Hibbing	151	149	131	83	78	592
Hopkins	62	68	24	26	24	204
Mankato	115	131	168	126	128	668
Minneapolis	65	730	588	414	380	2177
Moorhead	92	99	81	67	48	387
New Ulm	39	73	56	42	50	251
Red Wing	93	138	89	79	61	460
St. James	34	73	50	40	32	229
St. Paul	66	317	187	132	92	794
Slayton	23	27	30	30	27	137
Swanville	12	24	12	6	7	61
University High School	61*	57	59	37	48	262
Virginia	197	238	135	148	85	803
Worthington	48	64	37	38	35	222
Normal School students	..	..	..	..	..	33
University students	..	..	..	..	..	347
Totals	1489	2837	2361	1840	1568	10475

* Pupils who were examined in June as prospective University High School pupils.

In order to carry out comparative studies, control groups, consisting of several schools where no General Science is taught, were selected. One of these was the Johnson High School in St. Paul, with about 800 pupils.

The test was also given to 339 University of Minnesota students in Physics and Chemistry classes and to 33 Normal School students attending the summer session, 1922, at Moorhead Teachers College.

In September, 1922, 140 pupils in the University High School were retested with the same test. Results of the retest and of the original test were compared for purposes of securing some idea as to the stability or reliability of the measuring device in General Science with respect to a given group of individuals.

Procedure in handling the data.

(1) Fortunately, a graduate student and science teacher, reliable and systematic, was enlisted as a paid assistant to sort out and to score the entire set of approximately 11,000 tests. First, all test papers were sorted for the purpose of eliminating those in which vital data, such as name, age, classification of pupil, and answers to questions about courses previously taken by the pupil, were omitted. Then the assistant scored each test by means of celluloid stencils, the use of stencils facilitating the scoring and increasing the accuracy, and entered the total score made by each pupil on the upper right-hand corner of the first page of the test.

(2) After the tests were scored they were sorted according to (a) name of school, (b) the five grades within each school—8th, 9th, 10th, 11th and 12th, (c) sex of pupils in each of the classes, and (d) whether each pupil in each grade had or had not taken General Science. This meant that each grade might be divided into four groups, e. g., boys and girls who had taken General Science, and boys and girls who had not taken General Science. This made it possible to have each school divided into twenty groups in order to facilitate the handling of data in the different group studies.

Since experimental work with the test results of these groups occupies a large portion of this study, considerable time would be saved by the use of a few descriptive terms for naming

each of the twenty groups. Therefore, since this study has to do with General Science achievement, it was decided to use the symbol "+" to characterize any group of pupils who *had* taken General Science, while any group of pupils who *had not* taken General Science was characterized by the symbol "—". Then, by adding to the "+" or "—" the sex initial, e. g., "G" or "B" for girls or boys respectively, and the grade number, e. g., 8th, 9th, 10th, 11th, 12th, a complete descriptive term for any one of the twenty groups was established. To illustrate, "—8B" is interpreted in this study to mean 8th grade boys who had not taken General Science, and "+11G" is interpreted to mean 11th grade girls who had taken General Science. This system of nomenclature is used throughout the study in text, tables and figures.

(3) Test score, age, length of time in school, time taken in doing the test, science courses taken, whether or not the pupil liked science, and mental test score (when available) were then tabulated for the different schools in terms of the twenty different groups already described.

(4) The frequency of correct responses for each of the 300 items of the test was secured by actual count of errors for each item in 1760 cases. The percentage of correct responses and the relative order of difficulty were secured for a group of 500 8th grade girls and for a group of 400 8th grade boys who had not taken General Science. Similar data were secured for groups of 430 9th grade girls and for 430 9th grade boys who had taken General Science. These data were then used as a basis for making three scales out of the original General Science test of 300 items. The number of cases taken for this part of the study was sufficient to give as accurate results as would be given by an infinite number of cases. In the study each group was divided into two parts and the percents of correct responses for the first part was compared with the whole. Rank order correlations between the two distributions were over .99.

(5) The distribution of scores and the median score in the General Science test were secured for each of the twenty groups of each of the twenty-two school systems. From a combination of the median scores and the distributions of scores for different schools, tentative grade norms for the General Science test were secured.

(6) *Statistical evaluations.*

The following are some of the correlations worked out for the purpose of establishing the reliability of the 300 item test as a measuring instrument in General Science.

(a) The corelation between intelligence test results and the results of the General Science test.

(b) The correlation between chronological age and the General Science test.

(c) The correlation between time in taking the General Science test and success in the test.

(d) The correlation between general scholastic success and the General Science test, University High School.

(e) The correlation between marks in General Science and the General Science test, University High School.

(7) One hundred and sixteen pupils for whom both test and retest results were available were studied for stability in response.

(8) The median score and distribution for + groups of pupils, pupils who had taken General Science, were secured. The same data were also secured for the — groups of pupils, pupils who had not taken General Science.

(9) Grade medians for 9th, 10th, 11th and 12th grade pupils who had taken General Science were compared with medians in the same grades for pupils who had not taken General Science, in order to isolate success in the General Science test due to having pursued a course in General Science groups under approximately similar conditions.

(10) Norms for pupils who had taken General Science in the 8th grade were compared with norms for those who had taken General Science in the 9th grade. The greater or less success of these pupils would tend to justify the placing of General Science up or down in the school curriculum, the latter being the tendency in junior high schools.

(11) A measure of the persistence of General Science material and of its acquisition in later science courses was secured from a study of the achievement of University and Normal school students, about 350 in number.

(12) Because not all of the pupils had been allowed sufficient time to complete the General Science test and because it was found that equally accurate comparisons could be made

on the basis of the first three pages (the first 221 items) of the test, all the usable papers—about 9,000 in number—were rescored and retabulated on the basis of the 221 items, and comparisons similar to those made with the 300 items were obtained.

(13) When the Scales had been made, for the purpose of comparing Scale and test scores for the same pupils and groups, a hundred of the original papers were selected at random from each grade for the + boys and were rescored on the basis of only the items in the Scale.

(14) Finally, two forms of the finished Scales were mimeographed and given to General Science pupils in three schools: (a) Central High School, Minneapolis, 250 pupils; (b) Stillwater High School, 140 pupils; and (c) University High School, 58 pupils. Two Scale Forms of equal difficulty were given to check up the reliability of the Scales themselves and to compare Scale Achievement with marks in General Science and intelligence test scores.

(To be Continued)

Opportunities for Field Instruction in Science

A new profession has been created by the demand for leaders in nature study for summer camps and resorts. To aid in supplying this need, opportunities for special study are offered in various sections of the coun... The Yosemite School for Field Natural History was opened at Yosemite National Park this summer. The number of students is limited to twenty, and two years of college work is required for entrance. The Museum of Natural History, New York City, has just established in the Palisades Interstate Park a museum of live insects, to offer field instruction in entomology. A course in field biology at Nawaka Lodge, in the Allegheny Mountains, is conducted this summer by the University of Pennsylvania. The course is promoted by the Pittsburgh Nature Study Club, composed of city school teachers.

Egypt, the Land of Alchemists

By Professor A. J. Hopkins, Amherst College.

In Alexandria, in Egypt, two peoples were gathered together: the practical Egyptian, with his love of technical skill and his devotion to hard work; and their conquerors, the Greeks —the dreamy, theory-loving Greeks. From this union of opposite natures Alchemy sprang.

The stolid Egyptian, counting forty centuries or more of a somewhat changeless civilization, was an ideal artificer. His religion, too, led on to the same end. He worshipped the Sun, the giver of life, and the Nile, the giver of fertility. Necessity is the mother of invention; and the Nile, constantly breaking through boundaries, made necessary the art of surveying—and therefore mathematics. Prophecy of the time of the Nile flood called for a calendar and astronomy and more mathematics. Navigation of the Nile in boats, the building of magnificent temples to their gods and palaces to their Pharoahs, brought all sorts of arts and trades. The result was that the Egyptian was characterized by skill in artizanship and most wonderful memories,—a statement which is true even today of the present native.

History.

Alexandria was founded by Alexander the Great, in 331 B. C., when he was only twenty-five years old. He had been, from thirteen to sixteen years of age, a private pupil of the great Aristotle, in the palace of his father, Philip of Macedon. Aristotle had lingered on at the Macedonian court until Alexander, then twenty-two, set out on his conquest of the world. Alexander the Great, therefore, brought with him into Egypt the teachings of his great tutor and companion, whom he had left only three years before. It will be recalled that Aristotle was the pupil of Plato; so that we have a perfect pedagogical genealogy from Plato to Aristotle to the illustrious Greek Academy and the world-famed library and gymnasium of Alexandria.

As Athens declined in the third century B. C., Alexandria became the "modern Athens," brilliant, wealthy, intellectual

and wicked beyond all the Mediterranian cities. Even after Egypt became a Roman province, in 30 B. C., this "Queen City of the Mediterranean" for four centuries more—until the rise of Constantinople—was the most noted city in intellectual activity of the early centuries of our era. Here began militant Christianity, and here also Alchemy was born.

ANCIENT ARTS.

From Gaul to Phoenicia, in all the Mediterranean civilization, there flourished at this time the practice of certain well known arts. With tin from the islands of the Cassiterides and copper from Cyprus, was formed bronze; from gold and silver the highly prized alloy electrum. Many alloys were possible, and many were produced, destined for the jewelry trade and for the decorative arts. Colored glasses were produced, pearls were imitated, and dyes, especially the far-famed "Royal Purple" were manufactured. Recipes for these arts, which are more or less color industries, are found in the Papyrus Leyden and in the Papyrus Holmiensis.

The alchemists at first were busied with the great dye industry, but gradually transferred their activity to the production of bronze colors on metals. It was at this stage that alchemy had its inception.

THEORIES OF ALCHEMY.

Plato's system of philosophy followed closely the mathematical conceptions of Pythagoras. The latter conceived, in number, universal principles, such as that $2 + 2$ always make 4, and that the ratio of the perimeter of the circle to the diameter was everlasting and unchangeable. Plato emphasized these relations by calling them not only universal but divine, and took a further step in establishing a universal principle in the material world—that which we call matter; and therefore, he said, there can be but one matter, everywhere and all inclusive. Since also there are four elements in order of excellence, earth, water, air and fire, what we consider differences in metals, as between lead and gold, must be due to accident or to the superimposing of the higher element of Fire, identified by him with color. There is no essential difference, no material difference, between lead and gold. How strange this sounds to a modern ear! Again, there is no quali-

tative analysis! Color is divine and the all-essential. Lead may be *transmuted* into gold by one who knows how to change its color to that of gold. Transmutation caused lead to become yellow, but this artificial yellow had the added power of yellowing. Alchemistic gold was therefore to be considered superior to natural gold, in that natural gold has only sufficient yellow for its own body, while alchemistic gold is able to transmit its yellow to other metals and thus improve them. All metals were believed to be striving to become gold, so that the task of the alchemist was said to be easy,—simply to assist the metals to attain the higher life, to become gold, towards which they are all tending.

This theory was Greek. It was inherited by the alchemists; not their invention. The alchemists' great glory was that they simply applied it to the metals with which they were working. In a word, the theory was one of the importance of color; of colors, too, with grades of excellence, colors as kinetic, aggressive qualities, the higher colors having the power of ferments or yeast or catalysers. The teaching that metals are striving to become gold-like followed the conception that man of the higher spirit—the spirit of fire—tends to become god-like. In every simple civilization nature has always been personified.

We must think that the alchemists were honest in their belief. They claimed that their transmutation was successful; and if we accept their own definition of gold, we are forced to conclude that it was so. Of course, we say now that their theory was wrong; but to them it was right, and moreover it came from the great master, Plato. This theory was accepted universally by the people of that time, and continued to rule the best minds of the ancient world long after alchemy was driven out of Egypt by the decree of Diocletian in 292 A. D. How short was the life of alchemy in the country of its birth! Yet for a thousand years it was the ruling thought of the civilized world.

PSEUDO-ALCHEMY.

In the thirteenth century we find alchemy establishing itself in Western Europe,—but how differently! The definition of gold, during those thousand years, had changed to our modern definition. Transmutation had become impossible; so that

these pretended alchemists started in France on a career of misrepresentation which has cast a baleful glamour over the whole subject. Unfortunately, up to a few years ago, this alchemy, so-called, of the middle ages, has been pictured to us as the real alchemy.

In the thirteenth century, Roger Bacon protested: "Alchemy may be compared to the man who told his sons that he had left them gold, buried somewhere in his vineyard; where they by digging found no gold, but by turning up the mold about the roots of the vines procured a plentiful vintage."

But still Raymund Lully, in his ecstasy, exclaimed: "If the sea were of mercury, I could color it all into gold." The Egyptian phraseology was still there, but comprehension of its significance was wanting.

PRESENT CONDITIONS IN EGYPT.

After the fall of alchemy, the expulsion of the alchemists, and the burning of their books, the Greek theories still lived. A few of the writings had been translated by the Syrians; but that which lasted longest—still lives in fact—was the art of making colored alloys and the bronzing of metals. Most wonderful of all was the discovery, which I made this past year, that men are still working in every town on the border of the Nile, attempting to "make gold,"—working in secret, as of old, each with his particular recipe, which shall tomorrow bring him great wealth.

Egypt changes very little. The ancient city of Alexandria is indeed gone. Internal dissensions and foreign wars had so sapped it strength that for centuries it was a deserted village, and today it lies twenty feet below the desert sand; but the new city of 400,000 inhabitants stands today with a similar people, the Greeks still the most powerful influence. The native Egyptian has been converted first to Christianity and then to Mohamedanism, but his nature, even his features, are the same, unchanged from the time of Tut-enkh-amen.

Syllabus in Minimum Essentials for Science Teachers

THE following Syllabus is issued to the State Normal Schools of Massachusetts as the minimum essentials which should be taught *normal school students* who are to teach science in the first six grades. It must be understood that this is *not* a course content for the *pupils in the graded schools.* In the "aims" of this syllabus it is stated that "The most important aim of this course is to develop within the future teacher a proper enthusiasm for science and scientific subjects. Such an objective is considered necessary for the following reasons:

"A rational amount of scientific knowledge is demanded at the present time in order to prevent a teacher from appearing ignorant or even ridiculous. Science is becoming so interwoven with modern daily life that many of its facts and principles are matters of common knowledge to the children of the present day. If the teacher is to maintain her reputation, she must at least keep fully up to date.

"A study of science develops an acquaintance with natural objects and natural forces which will prove a source of enjoyment to the teacher herself, as well as a very valuable teaching asset. Most children are keenly interested in all kinds of natural objects and like to take specimens to the teacher. With a little knowledge and sympathy on the part of the teacher, such enthusiasm may be fostered and developed into a strong incentive for study.

"A little science aids greatly in the teaching of other subjects, particularly civics, geography and hygiene. In fact, it is practically impossible to teach the two latter successfully without a basis of scientific knowledge. Work in hygiene is steadily increasing in our common schools, especially along the lines of nutrition, and the teacher's knowledge of the subject should be sufficient to make her an efficient helper, and even to carry on some of the work herself."

ANIMALS.

1. *Types of insects.*—Life histories of insects. Insects injurious to garden, orchard, and forests. Insects injurious to the household. Insects as disease carriers. Useful insects.

After students have learned the characteristics of the different

types of insects, a written report may be made of one of the following insects. The report should contain the life history of the insect, a description of the way in which it is adapted to its environment, and, if the insect is harmful, a statement of the methods that are commonly used to hold it in check. This report should be illustrated with sketches. Besides studying the living insect, where that is possible, reference books and government bulletins should be used.

codling moth
tent caterpillar
curculio beetle
peach-tree borer
apple-tree borer
San José scale
apple maggot
striped cucumber beetle
plant lice
asparagus beetle
European corn borer
cutworm
cabbage worm
cabbage-root maggot
flea beetle
Hessian fly
army worm
chinch bug
gypsy moth
brown-tail moth
elm-leaf beetle
tussock moth
currant worm
tobacco worm
cotton-boll weevil
bean weevil
blowfly
cheese or ham skipper
mosquito
clothes moth
carpet beetle
cockroach
bedbug
head louse
flea
ant
stable fly
larder beetle
Indian meal moth
granary weevil
bee
silkworm
lady beetle
calosoma beetle
ichneumon fly

2. *Spiders and their relatives.*—Learn the general characteristics of spiders and study their habits and economic importance.

3. *Birds.*—Identification of common species, habitat, and habits. Adaptation to environments. Migration. Winter residents. Useful birds. Harmful birds. Bird protection.

An outdoor study of birds which will lead students to become interested in their habits, will be of exceptional value to teachers on account of the many lessons on birds in grade readers. A study may be made of birds that live in given areas, such as birds of orchards, of woodlands, of fields, and of marshes. A special written report may also be made of the life and habits of a single bird. A chart on which may be written the names of the birds and the dates on which they are first seen during the spring months should be kept in a conspicuous place.

4. *Domestic birds.*—Varieties of domestic birds. Their uses. Care of domestic birds.

Students should become thoroughly familiar with domestic birds, so that they will be able to help pupils solve the various problems of their club work.

5. *Fur-bearing animals.*—Habits of fur-bearing animals. Value of fur-bearing animals. Control of animals injurious to man. Protection of useful animals.

Make a study of the wild animals found in the State; learn why some of them are protected by law. A study may be made of special topics, such as animals that hibernate, animals that live mostly under ground, animals that climb trees, animals that eat flesh, and the destruction of animals that are injurious. Students may also make reports of the life and habits of individual animals.

6. *Domestic animals.*—Varieties of domestic animals. Uses of domestic animals. Improvement in animals brought about by care and intelligent breeding. The Animal Rescue League. Society for the Prevention of Cruelty to Animals.

7. *One-celled animals.*—Life processes of one-celled animals. Value of one-celled animals to man. Diseases caused by one-celled animals.

Make a microscopic examination of one or more types of one-celled animals. Students should observe, so far as possible, how they move, take in food, get rid of waste, and reproduce. The resemblances and differences between the one-celled animals and animals of more complex structure should be continually borne in mind.

8. *Marine animals.*—Sponge. Starfish. Crab. Lobster. Squid.

An effort should be made, where it is possible, to have classes visit the shore for much field work. Besides studying marine animals for the purpose of gaining an interest in them, students should become familiar with the economic importance of marine animals to the State.

9. *Earthworms.*—Habits of earthworms. Their work in nature.

10. *Mollusks.*—Varieties of mollusks. Habits. Food. Value to man. Civic problems relating to mollusks.

11. *Fishes.*—Care of an aquarium. Varieties of fresh water fishes. Varieties of salt water fishes. Value of fish as food. Laws which regulate the catching of fish.

Study the habits of fishes by observing them in an aquarium. Learn how they move, feed, breathe; and study other life functions. The circulation of the blood may be seen by placing the tail fin of a fish under the low power of a microscope. Learn how fishes resemble other animals studied; also how they differ from them. Make a study of fish hatcheries and of their imortance to the State.

After students have learned the general characteristics of fishes, they may make individual reports. Each student may select a single fish. The report should contain the life habits of the fish and its value to man. A careful study should be made of all reference material available.

12. *Toads, Frogs, and Salamanders.*—Life history. Economic importance.

The metamorphosis of toads, frogs, and salamanders may be studied in the aquarium.

13. *Reptiles.*—Varieties. Habits. Work in nature.

14. *Bibliography.*—In addition to learning the use of reference books listed in the bibliography, students should become familiar with the lives and works of Darwin, Agassiz, Burroughs, and other leaders who have made valuable contributions to the study of animal life.

PLANTS.

1. *Autumn Wild Flowers.*—Varieties. Habitat. Method of identifying.

A careful study should be made of one or more types to help students obtain an idea of the relationships of plants.

2. *Pollination and Fertilization.*—Methods of pollination and fertilization. Relation of insects to plants. Formation of fruit. Dissemination of seeds.

Students may collect materials and make such exhibits as would be helpful in elementary school work.

3. *Cultivated Flowers.*—Identification. Uses in outdoor beds or borders and for indoor decoration.

Study varieties which are especially well adapted to withstand the early autumn frosts. Gather and preserve seeds for next year's planting.

4. *Harvesting garden products.*—Kinds of vegetables produced in the home garden. Judging vegetables and fruits. Storing vegetables and fruits.

Learn to select good types of garden products such as are commonly placed on exhibition by boys and girls in the annual club exhibits.

5. *Weeds.*—Habitat. Ways of distribution. Annuals. Biennials. Perennials. Methods of control.

6. *Bulbs.*—Varieties. Growing bulbs in water. Growing bulbs in flower pots. Growing bulbs outdoors.

Learn how to obtain a succession of flowers by planting different varieties, by planting the same varieties at different times, and by bringing some bulbs from storage earlier than others.

After learning the characteristics which are common to the different varieties of bulbs, each student may select and plant one variety. A report should be made of the care which must be given the bulbs to make them flower successfully.

7. *The garden after harvesting.*—Removing rubbish. Fertilizing. Plowing.

On account of the cornstalk borer and other pests, which live over winter in stalks, roots and vines that remain on the ground after the crops are removed, all such material should be burned and the garden should be plowed just before the beginning of winter.

8. *Trees.*—Recognition of native trees. The value of forests to man. Forest planting. Forest protection.

A special effort should be made to recognize trees by their leaves. This work should begin early enough in the autumn so that collections of leaves may be made. Students should learn to preserve leaves for room decoration.

9. *House plants.*—The window garden. The growing of plants in pots. Propagation of house plants, slips and cuttings. Potting and repotting plants. Window boxes and hanging baskets.

The windows in the normal school laboratory should serve as a model for what students may later use in public school windows. An effort should be made to have a succession of plants which can be grown successfully in any school or home window. Students should also grow plants in their own home windows. They should realize that the ultimate aim of training children in school is to help make them successful in their efforts at home.

10. *Planting plans for school and home grounds.*—Ornamental trees. Shade trees. Shrubbery. Vines. The perennial border.

After making a study of a number of school and home grounds in the neighborhood, each student should prepare at least one planting plan for school grounds and one for home grounds. Students should also be led to form the habit of observing the care required by the plantings during the entire year.

11. *One-celled plants—Bacteria. Yeasts. Molds.*—Bacteria in milk Bovine tuberculosis in human beings. Testing cows with tuberculin. Grading milk. Certified milk. Pasteurized milk. Cold storage of foods. Refrigeration. Preserving foods. Fungous diseases of plants and their control. Value of bacteria, easts and molds in the preparation of foods.

Students should learn how to examine bacteria, yeasts and molds with a compound microscope. They should also learn how to prepare such cultures as may be seen easily by pupils in the grades.

12. *Other spore-bearing plants.*—Mushrooms. Seaweeds. Mosses. Lichens. Ferns. Life histories of plants. The ascending series of plants.

Learn the relations which exist between the lowest spore-bearing plants and the highest seed-bearing plants.

13. *Trees.*—Winter condition. Bark. Buds.

14. *Fruits, nuts, and spices.*—Native. Imported. Study economic importance.

15. *Seeds.*—Germination. Storage of food in seeds. Seed testing. Study structure of types of seeds and conditions necessary for germination.

16. *Roots.*—Structure. Functions.

Study how they obtain and transport food materials from the soil and how they store food for the growth of young plants.

17. *Stems.*—Structure. Functions.

Distinguish between the structure of monocotyledonous and dicotyledonous stems, and study the value of different parts of stems for lumber and other uses. Learn plant propagation by means of stems. Make a study of trees, vines, and shrubs in their early spring condition.

18. *Leaves.*—Structure. Functions.

Study value of leaves to plants, and the economic uses of leaves for food, beverages, and medicinal purposes.

19. *Flowers.*—Structure. Function.

Learn to recognize spring flowers as they make their appearance. This work should begin with the earliest flowers and continue until the close of school. Special attention should be given to flowers that are in danger of becoming extinct.

20. *Plant families.* Classification.

Learn leading characteristics of several plant families. Make a study of several plants in each family, to show how the plants are related. Learn the meanings of scientific names of plants as given in seed catalogues.

21. *Cold frames, hot-beds, and the garden.*—Preparing the soil. Planting and transplanting. Cultivating. Companion and succession crops. Crop rotation. Pests and diseases.

In addition to learning how to plant and to take care of the crops commonly grown in home gardens, each normal school student should plant one or more kinds of vegetables and take care of them until the close of school. Students should also be shown how to help pupils in the training school to plant and cultivate crops. At the close of school seedlings may be distributed to normal school students and to pupils in the training school.

22. *Improvement of existing varieties of plants.*—Study lives and works of Mendel, Burbank, and others who have made valuable contributions to improvement of plant varieties.

PHYSICAL SCIENCE.

1. *The air.*—A form of matter. Air and combustion. Relation to plant life. Pressure. Vacuum. Respiration. Barometers. Pumps. Relation to storms. Moisture in air. Clouds. Rain. Weather and climate. Weather signs.

2. *The earth.*—Common minerals,—quartz, felspar, mica, hornblende. Common rocks,—sandstone, granite, limestone, slate. Soil making,—sand, gravel, clay, humus. Past history of the earth. The coal series.

3. *The heavens.*—The solar system: Phases of the moon. Earth. Their motions. Night and day. Seasons. Eclipses,—lunar, solar, annular, partial, total. Stars,—constellations, big dipper, little dipper, polar star, meteors, comets.

4. *Water.*—Surface bodies. Underground waters. Capillarity. Water cycle. Water table. Wells. Springs. Safe wells. Sources of pollution. Hard and soft water.

5. *Heat.*—Natural and artificial sources. Properties. Conduction, convection and radiation. Fireless cooker. Thermos bottle. Specific heat. Latent heat. Effects of heat. Measurement of heat. Temperature. The thermometer. Heat a form of energy. Systems of heating. Methods of refrigeration. Uses of clothing. How to distinguish textile fibers.

6. *Light.*—Sources. Properties. Reflection and refraction. Variation in intensity. Relation to other forms of energy. Common optical instruments,—camera, simple microscope, field glasses, eye glasses.

7. *Gravitation.*—Gravity. Weight. Density. Buoyancy. Pressure. Tides. Pendulum.

8. *Sound.*—Cause. Transmission. Pitch. Quality. Voice. Music. Musical instruments.

9. *Magnets.*—Natural and artificial. Magnetic field. Law of magnets. The compass.

10. *Electricity.*—Proerties. Electromagnets. Cells,—wet, dry and storage. Generators. Hydro-electricity. Units of measure,—volt, ampere, watt, watt-hour, kilowatt hour. Common uses,—electric bell, electric iron, electric light. Danger of short circuits. Fuses.

11. *Common Machine Principles.*—Levers. Wheel and axle. Gears.

12. *Common Household Chemicals.*—Soda. Salt. Baking powder. Ammonia. Soap. Blueing. Dyes. Acids. Gases and salts.

13. *Simple Chemical Action.*—Oxidation. Fire. Fire hazards. Fire prevention. Rich and lean mixtures of gas for the auto. Neutralization. Chemical action. Simple equations.

14. *Important Metals.*—Iron. Aluminum. Copper. Silver. Alloys.

15. *Compounds of Carbon.*—Foods: Classes, value of each to body, composition.

16. *Disinfectants and Preservatives.*

17. *Biography.*—Lives of Bell, Edison, Pupin, and others.

The matter of correlation of Science with other studies in the grades is treated in a paragraph which is herewith quoted:

CORRELATION OF SCIENCE WITH OTHER STUDIES IN THE GRADES.

"Science is closely related to other studies in the grades. A study of the lessons in any lower grade reader will reveal the fact that practically all of the lessons have been taken from nature. They deal with subject matter of both living and non-living things. The material in the readers may to some extent determine the selection of material for the science lessons. Birds, dogs, squirrels, hens, frogs, fish, rabbits, tur-

tles, stars, the moon, are all familiar topics commonly used in lower grade readers. The science lessons should precede the reading lessons which are based on them. If the robin is to be the subject for a reading lesson, a study of the robin that will lead the children to become interested in it before beginning the lesson in the reader, will prove to be of material help to the child in learning the words or the formal part of reading for which the lesson in the book is intended.

"In the science lesson children are led to observe things accurately and then tell what they have seen in correct English. Thus, every lesson in science is a language lesson. The written language lesson may be based entirely on the lesson in science. The language period may be used for the science study one day, and followed with a written lesson in what they have observed the next day.

"Science and geography may be combined in a study of the physical features of the home environment. Observations made by children in the primary grades serve as an introduction to the study of elementary geography. The study of the material with which the children come in contact daily leads to an interest in a study of the world as a whole. Science and geography also go hand in hand in giving children an understanding of the problems involved in supplying the needs of humanity. An understanding of the way in which problems are dealt with at home leads pupils to an appreciation of their dependence on the world as a whole.

"History in the upper grades deals continually with progress that has been made by means of scientific inventions. Children delight in imitating the crude methods used by man in earlier days. While a study of such methods leads to interest in history, it is also evident that the child can learn the principles of science more easily from simple experiments than by a study of the complicated modern machines."

This Syllabus was prepared by a committee made up of Mr. William H. D. Meier, State Normal School, Framingham, Mass.; Mr. Walter G. Whitman, State Normal School, Salem, Mass.; and Mr. Charles B. Wilson, State Normal School, Westfield, Mass.

Training of the General Science Teachers in Missouri

By E. J. Roseman, A.M.,
Graduate Student in Education, University of Missouri.

Introduction.

The purpose of this study is to point out the pertinent aspects of the training of the General Science teachers in Missouri who were teaching during the school year 1924-25. It deals primarily with the number of subjects taught by the General Science teachers in the first class high schools of the state, and with the academic and professional training which these teachers had had for the particular subjects which they were teaching. A study of tenure has also been made. Tenure, while bearing indirectly upon the problem, is nevertheless very necessary to a complete understanding of the situation.

This paper is based on information gained from the high school teachers of Missouri. In the fall of 1924 the writer sent out 3,100 questionnaires to the teachers in first class high schools of Missouri for the purpose of securing information in regard to their training. Replies were received from 1,152 teachers, 115 of whom were teachers of General Science. The replies received from these General Science teachers have furnished the basis of the study to follow.

Returns were secured from schools of various sizes, and for this reason the schools have been placed in four groups, according to enrollment. Schools in Group I are those having enrollments of 250 or more. Schools in Group II are those having enrollments of 150 to 249. Schools in Group III are those having enrollments of 75 to 149. Schools in Group IV are those having enrollments of 75 or less. The following method of grouping will be used throughout this paper:

Group	*Enrollment*
I	250 or more
II	150-249
III	75-149
IV	75 or less

As stated above, replies were received from 115 teachers of General Science, from schools of various sizes. The numbers of teachers reporting in each group are as follows:

Group	*No. of Teachers in each Group*
I	29
II	19
III	30
IV	37
Totals	115

The following phases of the problem will be discussed in the order mentioned:

A. The Teachers' Programs.
B. Special Academic Training.
C. General Academic Training.
D. Professional Training.

A. The Teachers' Programs.

In the questionnaire the teachers were requested to list the number of subjects which they were teaching during the first semester of the school year 1924-25. It might be well to mention here that subject is used to designate any of the well recognized divisions of knowledge, e. g., Science, Mathematics or English.

From the Information gained in the questionnaires Table I was prepared. Table I is a percentage distribution showing the extent to which General Science appears singly and in combination in each group. This table shows that 24.1 per cent of the General Science teachers reporting in Group I teach General Science as a single subject; that 44.8 per cent teach General Science in a two-subject combination; 27.6 per cent in a three-subject combination, and 3.5 per cent in a four-subject combination. In Group II, 10.5 per cent of the 19 teachers reporting teach General Science as a single subject, 47.3 per cent in a two-subject combination, etc. A glance at the totals shows that only 8.6 per cent of the teachers teach General Science as a single subject, 35.6 per cent teach it in a two-subject combination, 39.1 per cent in a three-subject

combination, 13.9 per cent in a four-subject combination, and 2.6 per cent teach it with four other subjects.

Table I shows that the number of subjects per teacher varies inversely with the size of the school. As shown in the table, 32.4 per cent of the teachers of Group IV would be required to make two daily preparations, 48.7 per cent three daily preparations, 10.8 per cent four preparations, and 5.4 per cent five preparations. It is evident, then, that the teachers in the small schools must necessarily be much less efficient than the teachers in the large schools, where they are not required to make so many daily preparations.

These figures become more significent when we realize that teachers are trained to teach one or at most two subjects. Teacher-training institutions do not profess to train teachers for as many subjects as Table II shows them to be teaching. It is evident that many General Science teachers are teaching subjects for which they cannot possibly have had adequate preparation.

TABLE I.

Percentage Distribution to Show the Extent to which General Science Appears Singly and in Combination in Each Group.

Group	Number of Teachers	Percentage of times each subject occurs: As a single subject	Two-subject combination	Three-subject comb.	Four-subject comb.	Five-subject comb.
I	29	24.1	44.8	27.6	3.5	..
II	19	10.5	47.3	36.7	5.5	..
III	30	..	23.3	40.0	33.3	3.4
IV	37	2.7	32.4	48.7	10.8	5.4
Totals	115	8.6	35.6	39.1	13.9	2.6

The information shown in Table I becomes even more significant after an examination of Tables II and III, showing years of experience in present position and total years of experience, respectively.

Table II shows that 25 per cent of the 29 teachers reporting in Group I have had less than .47 years of experience in their present positions; that 50 per cent have had less than .96 years of experience in their present positions, 75 per cent less than 1.96 years and the remaining 25 per cent more than that num-

ber. A glance at the totals for all groups combined shows that 25 per cent of the 115 teachers reporting have had less than .47 years of experience in their present positions, 50 per cent less than .94 years, 75 per cent less than 1.98 years, and the remaining 25 per cent more than that number.

TABLE II.

Years of Experience which General Science Teachers Have Had in Their Present Positions.

Group	No. of teachers reporting	First quartile	Median	Third quartile
I	29	.47	.96	1.96
II	19	.67	1.50	1.66
III	30	.42	.84	1.75
IV	37	.45	.88	1.85
Totals	115	.47	.94	1.98

Table III shows that the total teaching experience of 25 per cent of the 29 teachers of Group I is less than 1.37 years, of 50 per cent less than 3.16 years, of 75 per cent less than 6.74 years, and of the remaining 25 per cent more than that number. A glance at the totals shows that 25 per cent have taught less than 1.36 years, 50 per cent less than 2.91 years, 75 per cent less than 7.66 years, and the remaining 25 per cent more than that amount.

TABLE III.

Total Number of Years of Experience which General Science Teachers Have Had.

Group	No. of teachers reporting	First quartile	Median	Third quartile
I	29	1.37	3.16	6.74
II	19	1.68	2.70	7.13
III	30	1.07	3.42	8.50
IV	37	1.76	4.52	7.75
Totals	115	1.36	2.91	7.66

An examination of Tables II and III seems to indicate that in the case of General Science teachers there is no definite relation between size of school and amount of teaching experience. Table II shows that 25 per cent of the teachers of Group I have had less than .47 years of experience in their present positions, while the corresponding 25 per cent of the teachers of Group II have had .67 years of experience in their present positions. Further examination shows that the median number of years of experience in present position for teachers of Group III is also larger than that of Group I. A

similar relationship is found between the experience of teachers in Groups III and IV. Similar irregularities appear in Table III. In the light of the data presented in Table I, these conditions are entirely unexpected. Table I reveals the fact that the subject combinations of the teachers in the larger schools are much more regular than those in the smaller schools, consequently the positions in the larger schools are most desirable and less shifting of teachers is to be expected. The data presented in Tables II and III, however, show no correlation between years of experience and difficulty of teaching position. The tables do, however, indicate that the turnover of General Science teachers is very frequent and the tenure uncertain.

In Table II we are shown the number of subjects taught by the teachers of General Science. Feeling that a knowledge of these combinations is not sufficient, the writer has gone one step farther and prepared Table IV, which shows the exact combinations which are taught. This table is a percentage representation of the relative frequency with which General Science appears in combination with other subjects. In point of frequency, Physics and Mathematics rank first, occurring with General Science 21.83 per cent of the time. Agriculture ranks second, occurring 19.54 per cent of the time; Physical Education ranks third, etc.

TABLE IV.

Percentage Representation of the Relative Frequency with which General Science appears in Combination with Other Subjects.

SUBJECT	Percentage
English	4.02
History	8.04
Mathematics	21.83
Physics	21.83
Chemistry	8.04
Biology	2.29
Agriculture	19.54
Industrial Arts	1.14
Fine Arts	1.14
Home Economics	.57
Latin	1.72
Modern Languages	...
Teacher Training	...
Commercial Subjects	1.14
Physical Education	8.62
Totals	99.99

Table IV shows that General Science occurs in thirteen different combinations. Beginning at the left, we find the following combinations represented: General Science-English, General Science-History, General Science-Mathematics, etc. The General Science-Home Economics combination was found to be a non-recurring combination, i. e., occurred only once. The remaining combinations are recurring.

B. Special Academic Training

Having studied the problems which the teachers of General Science must face, we are now curious to learn how well they are able to meet the situation. Accordingly, this section of the paper dealing with special academic training has been written.

The Committee of Seventeen, a committee of the National Education Association on the preparation of high school teachers, recommended "a detailed and specialized study of the subjects taught."[1] This statement may be regarded as one of the most authoritative statements in regard to the special preparation of teachers for the subject taught:

"Special knowledge of an advanced nature in the fields in which the candidate proposed to teach, is an absolute necessity. It cannot be emphasized too much that the persons who desires to teach in our high schools must know that which he is to teach."[2]

Table V shows the number of semester hours of preparation in Science which the General Science teachers have had in higher institutions. This table shows that the preparation of 25 per cent of the teachers reporting in Group I is less than 19.0 semester hours, of 50 per cent less than 31.0 semester hours, of 75 per cent less than 52.7 semester hours, and of the remaining 25 per cent more than that amount. The preparation of 25 per cent of 17 teachers reporting in Group II is less than 28 semester hours, of 50 per cent less than 40.3 semester hours, of 75 per cent less than 44.8 semester hours, and of the remaining 25 per cent more than that amount. The totals show that the preparation of 25 per cent of the

1 Proceedings of the N. E. A., 1907, pp. 523 ff.

2 Cubberley, Ellwood P., Preparation of High School Teachers. Proceedings of the N. E. A., 1907, pp. 556 ff.

110 teachers who reported their special training is less than 18.7 semester hours, of 50 per cent less than 29.3 semester hours, of 75 per cent less than 42.7 semester hours, and of the remaining 25 per cent more than that amount.

Table V seems to indicate that the teachers of General Science conform fairly well to the recommendation of the Committee of Seventeen, i. e., "a detailed and specialized study of the subjects taught." These teachers also appear to meet the requirements of the State Department of Education, i. e, fifteen semester hours in Science with a minimum of five hours in biological science and a two-hour course in the teaching of Science.[3]

TABLE V.

Number of Semester Hours of Preparation in Higher Institutions for the Subjects Taught.

Group	No. of teachers reporting	First quartile	Median	Third quartile
I	25	19.0	31.0	52.7
II	17	28.0	40.3	44.8
III	31	18.8	25.6	37.8
IV	37	17.8	26.2	37.7
Totals	110	18.7	29.3	42.7

Attempts at the present time are being made to reorganize the General Science course for the purpose of making it general in the strictest sense of the word. Proponents of the reorganization scheme insist that in the past General Science teachers have all too often been specialists in either Physics or Chemistry, and consequently have failed to realize the objectives of General Science teaching.

The fact that Table IV shows 21.82 per cent of the General Science teachers to be Physics teachers, 8.04 per cent to be Chemistry teachers, 19.54 per cent to be Agriculture, etc., would seem to indicate that these teachers are specialists in their particular fields. Feeling that the exact preparation which General Science teachers have had in the several sciences would be necessary for a complete understanding of the situation, the writer has prepared Table VI. The figures in Table VI following the group numbers represent the number of teachers reporting in each group. This table shows that 25 per

3 Department of Education, State of Missouri. "Organization and Administration of High Schools," p. 33, 1924.

cent of the General Science teachers reporting in Group I have had less than 7.1 semester hours of credit in Chemistry, 50 per cent have had less than 10.2 semester hours, 75 per cent less than 20.7 semester hours, and the remaining 25 per cent more than that amount. Of the 17 teachers reporting in Group II, 25 per cent have had less than 4.2 semester hours of credit in Chemistry, 50 per cent less than 15.1 semester hours, 75 per cent less than 20.8 semester hours, and the remaining 25 per cent more than that amount, etc. A glance at the totals shows that 101 of the General Science teachers have had some work in Chemistry. The preparation of 25 per cent of the total number reporting work in Chemistry is less than 4.5 semester hours, of 50 per cent less than 10.3 semester hours, of 75 per cent less than 18.7 semester hours, and of the remaining 25 per cent more than that amount.

An examination of the totals for all subjects in Table VI, shows that 101 teachers have had preparation in Chemistry, 88 in Physics, 65 in Agriculture, 58 in Botany, 52 in Zoology, 12 in Geography, 10 in Biology, 4 in Physiology, and 5 in Bacteriology.

TABLE VI.

Preparation by Groups which the General Science Teachers Have Hal in Other Sciences.

SUBJECT			First quartile	Median	Third quartile
Chemistry	I	(25)	7.1	10.2	20.7
	II	(17)	4.2	15.1	20.8
	III	(26)	4.1	9.6	16.6
	IV	(33)	3.9	9.4	17.8
Totals		(101)	4.5	10.3	18.7
Physics	I	(20)	6.5	9.3	13.5
	II	(17)	8.0	10.7	13.7
	III	(22)	6.6	8.9	12.3
	IV	(29)	7.2	10.1	16.8
Totals		(88)	7.1	9.6	14.4
Agriculture	I	(11)	4.5	10.1	22.5
	II	(11)	4.5	15.1	22.5
	III	(18)	7.9	12.6	18.5
	IV	(25)	8.7	14.7	19.4
Totals		(65)	7.9	13.2	19.4
Biology	I	(4)	2.5	11.0	18.5
	II	(0)	..	..	..
	III	(1)	..	12.5	..
	IV	(5)	1.5	1.9	5.8
Totals		(10)	2.0	4.1	12.5

TABLE VI (*continued*)

Zoology	I	(15)	2.3	4.7	9.3
	II	(6)	2.5	3.0	26.3
	III	(21)	1.4	2.9	5.4
	IV	(10)	2.0	4.1	8.5
Totals		(52)	1.8	3.7	8.0
Botany	I	(16)	2.5	5.0	10.0
	II	(7)	1.4	2.9	5.4
	III	(19)	1.5	2.9	5.5
	IV	(16)	1.4	2.9	4.3
Totals		(58)	1.8	3.3	5.9
SUBJECT			First quartile	Median	Third quartile
Geography	I	(1)	1.2	2.5	3.6
	II	(3)	1.2	2.5	4.7
	III	(3)	1.8	3.7	7.3
	IV	(5)	2.0	4.1	15.0
Totals		(12)	1.6	3.3	6.0
Physiology	I	(0)	..	..	..
	II	(0)	..	..	..
	III	(1)	..	2.5	..
	IV	(3)	1.8	3.7	7.2
Totals		(4)	1.6	3.3	6.0
Bacteriology	I	(0)	..	..	..
	II	(0)	..	..	..
	III	(1)	..	2.5	..
	IV	(4)	1.8	3.7	7.2
Totals		(5)	1.6	3.3	6.0

The number of subjects in which General Science teachers have had preparation and the extent of that preparation is shown to better advantage in Table VII. A study of Table VII reveals the fact that General Science teachers are essentially teachers of Physics, Chemistry and Agriculture. The fact that the median amount of training which the teachers of General Science have had in Agriculture ranks first among the sciences listed is probably due to the large number of teachers who are also teaching Vocational Agriculture under the Smith-Hughes Act, the requirements for which are the four-year course prescribed by the State Board of Education.[4]

4 Department of Education, State of Missouri. "Organization and Administration of High Schools, 1924, p. 34.

TABLE VII.

Median Preparation which the General Science Teachers Have Had in the Various Sciences.

SUBJECT	Number of Teachers Reporting	Median Amount of Preparation
Chemistry	101	10.3
Agriculture	65	13.2
Physics	88	9.6
Botany	58	3.3
Zoology	52	3.7
Geography	12	3.3
Biology	10	4.1
Physiology	4	3.3
Bacteriology	5	3.3

C. General Academic Training.

The Committee of Seventeen also recommended that "the program of studies selected by each student should include work in subjects outside of those in which he is making special preparation, sufficient to give some insight into the different fields of knowledge and to avoid the dangers of over-specialization." The committee further recommended "that the minimum requirement for a secondary school teacher be graduation from a college maintaining a four-year course and requiring four years of high school work for admission."[5]

Table VIII shows the extent to which the General Science teachers live up to this recommendation. This table shows that the general academic preparation of 25 per cent of the teachers of Group I is less than 100.0 semester hours, of 50 per cent less than 109.7 semester hours, of 75 per cent less than 127.7 semester hours, and of the remaining 25 per cent more than that amount. The preparation of 25 per cent of the teachers of Group II is less than 89.0 semester hours, of 50 per cent less than 100.0 semester hours, of 75 per cent less than 109.6 semester hours, etc. A study of the totals shows that the preparation of 25 per cent is less than 89.8 semester hours, of 50 per cent less than 100.0 semester hours, of 75 per cent less than 113.8 semester hours, and of the remaining 25 per cent more than that amount.

It must be remembered that Table VIII does not include professional training. The general academic preparation of those teachers who have selected Education as their major sub-

5 Proceedings of the N. E. A., 1907, pp. 523 ff.

ject, i. e., who have 24 semester hours of professional credit, would have to be 96 semester hours in order to give them a grand total of 120 semester hours.

TABLE VIII.

General Academic Training of the Teachers of General Science.

Group	No. of teachers reporting	First quartile	Median	Third quartile
I	29	100.0	109.7	127.7
II	19	89.0	100.0	109.6
III	30	84.3	98.5	111.0
IV	37	86.7	96.5	107.7
Totals	115	89.8	100.0	113.8

The extent of the general academic training is shown to better advantage in Table IX. This table shows that 1.73 per cent of the 115 teachers reporting have the degree of Master of Arts, 38.26 per cent that of Bachelor of Science, 21.73 per cent that of Bachelor of Arts. Those teachers who have both the Bachelor of Science and the Bachelor of Arts degrees are included in Table IX under the professional degree only. Thus this table shows that 61.72 per cent of the 115 General Science teachers conform to the recommendations of the Committee of Seventeen, i. e., they have had four years of college training.

TABLE IX.

Percentage Representation according to the Number of General Science Teachers who have the Various Degrees.

	Percentage with the Various Degrees			
No. of Teachers	A.M.	B. S.	A. B.	Totals
115	1.73	38.26	21.73	61.72

D. Professional Training.

Probably one of the foremost elements leading to ineffective teaching is failure on the part of the teacher to appreciate the pupils' point of view. "A large majority of them give greater attention to the logical development of the subject than to the development of the logical powers of the pupil. This is due to the fact that the training of these teachers has been largely, if not wholly, academic, and that their profes-

sional training, if they have had any, has been incidental and superficial. Professional training, as here used, means the study of the subject with reference to its adaptability to use as an instrument of developing and training the mind of the pupil."[6]

The most recent and probably the most authoritative statement in regard to the professional training of teachers is that of the North Central Association of Colleges and Secondary Schools. That body recommended that "the minimum professional training of a teacher of any academic subject, and the supervisor of such subjects, shall be 11 semester hours in Education. After September 1, 1925, this requirement of the State Department of Education is also 15 semester hours.

Table X shows the extent to which the teachers of General Science measure up to these standards. This table shows that the professional preparation of 25 per cent of the teachers of Group I is less than 17.6 semester hours, of 50 per cent less than 25.0 semester hours, of 75 per cent les than 35.3 semester hours, and of the remaining 25 per cent more than that amount, etc. A glance at the first quartiles of Groups II and III shows that 25 per cent of the teachers in these two groups have slightly less than the 15-hour requirement. An examination of the totals, or figures for all groups combined, shows that 75 per cent have had more than 16.6 semester hours of professional training. To be more exact, 76.8 per cent of the General Science teachers meet the professional rquirement of 15 semester hours.

TABLE X.

Professional Training of the Teachers of General Science.

Group	No. of teachers reporting	First quartile	Median	Third quartile
I	29	17.6	25.0	35.3
II	19	13.1	26.0	38.9
III	30	14.6	21.8	33.0
IV	37	16.2	24.4	30.3
Totals	115	16.6	24.2	31.0

6 Brooks, Stratton D., Proceedings of the National Education Association, 1907, pp. 547 ff.

CONCLUSION.

The above facts point to the following conclusions:

1. There has been a tendency toward specialization in Physics, Chemistry and Agriculture. This specialization has resulted in training which has not been sufficiently general for a realization of the objectives of General Science teaching.

2. Few science teachers are fitted to teach combinations of sciences.

3. Twenty-three and two-tenths per cents of the teachers fail to measure up to the generally accepted standards.

4. General Science teachers, especially in the smaller schools, are teaching more subjects than they can possibly be qualified to teach.

5. Many of the teachers in schools of all sizes have had no previous experience; many are found who are teaching in their present positions for the first time.

6. The rapid turn-over of General Science teachers in schools of all sizes indicates that their tenure is very uncertain.

7. There is no definite correlation between tenure and difficulty of teaching program.

8. Subject combinations are in a chaotic condition, showing practically no standardization.

9. The number and variety of subject combinations present a difficult problem to the teacher-training agencies of the state.

Yeast Not Needed in Ordinary Diet

Yeast is not necessary for a person whose diet contains vegetables, fruits and the dairy products, says *Hygeia*, popular health magazine published by the American Medical Association, in its October issue.

In reply to a Pennsylvania woman who asks about yeast, *Hygeia* declares that a diet which contains the necessary vitamins need not be supplemented by yeast. It points out that although it acts as a laxative in many cases, it causes, not unfrequently, an unpleasant distention of the bowels.

Through the Ages of Time

By O. E. Underhill, Normal School, Salem, Mass.

(This is the fifth of a series of question and answer lessons in general science.)

Teacher. How do you know when it is time to start for school, John?

John. I start when the clock says it is twenty minutes to eight.

Teacher. How can the clock tell you when it is time to go to school?

John. Why, it tells time.

Teacher. What *is* time? What do you mean when you say that the clock "tells time"?

Mary. It marks off the minutes.

Teacher. What are minutes, Mary?

Mary. They are parts of an hour.

Teacher. And what are hours?

Mary. They are parts of a day. The days are divided into hours.

Teacher. Yes. The earliest divisions of time were probably the days. What is it that divides time into days?

Charles. The rising and setting of the sun.

Teacher. Do you mean that the sun moves?

Charles. Oh, no. The earth turns around. This makes it seem to us as if the sun moved.

Teacher. That is right, Charles. The rotation of the earth marks off the days. The motion of the moon was also used to mark time off into periods. You know the Indians used to speak of a period of time as so many moons. In Longfellow's *Hiawatha* it speaks of the moon of snowshoes, the moon of falling leaves, and the moon of strawberries; then there are the lines:

"Four great logs had he for firewood,
One for each moon of the winter."

These periods of time marked off by the changes of the moon are what form the basis of our present months. What determines the length of time which we call a year?

Charles. The earth moves around the sun every year.

Teacher. That is right. But years and months and days, which are natural periods of time, are not enough. We must have surer means than those of telling time. When we run our railroad trains we must be very accurate indeed, if we are to avoid accidents. So we have clocks or watches. We might say then that a clock was something to divide the day into small equal periods of time. Do you suppose that we have always had clocks and watches like those we now have, Mary?

Mary. I shouldn't think so.

Beatrice. When were clocks first used?

Teacher. The first successful clock of the type that we have today was first erected by a German in the palace of King Charles V of France in 1379. That was before America was discovered, you see.

Alice. How could one tell time before clocks were invented?

Teacher. Does anyone know of any other ways of telling time than by means of clocks?

Dora. In the garden of the big house up on the hill there is a sun-dial.

Teacher. And how does that tell time?

Dora. There is a little board that sticks up in the center of a little table. It casts a shadow, and the place where the shadow falls marks the hour.

Teacher. That is probably the oldest form of a timepiece. Probably, thousands of years ago, some savage stuck a stick in the ground and watched the shadow of this stick move along as the sun traveled across the sky overhead. But it is not a very accurate method, and the position of the shadow changes somewhat at different times of the year. Then, too, it would not be very convenient to carry around, as the dial must be pointed exactly in a certain direction.

Frank. My sister has a little sun-dial watch that she carries around.

Teacher. Have you seen her use it, Frank?

Frank. No, I haven't.

Teacher. You would find that with the sun-dial is a little compass. There is also a set of directions which tells her in what direction she must hold the watch, depending on what part of the country she is in and what part of the year it is.

Telling time by means of the sun-dial is mentioned in the 38th chapter of Isaiah.

Perhaps some of you would like to make such a sun-dial at home. In some of the older houses you may find a sun-dial cut on a window-sill, so that the shadow of the edge of the window will tell the time.

Dora. When my mother wants to boil eggs just three minutes, she has a glass full of sand, and it runs from one end to the other in three minutes. I will bring it to school if you wish.

Teacher. That is also a very old way of telling time. How many of you have not seen an hour-glass? Quite a number. Then, Dora, I will be very glad to have you bring the glass tomorrow, so that we may all see it. A very long time ago the Romans had such glasses made so that it took an hour for the sand to run through. The Romans used such a glass to time speakers when they were debating or arguing in the courts. Speakers were allowed different amounts of sand, according to their importance.

It is said that King Alfred, who lived about 800 A. D. (let's see—that was—200 makes a thousand and 925 more—that makes over 1100 years ago), measured time by the shortening of a lighted candle. I think it was this king who gave candles to his different generals during a certain battle, with orders to attack when the candles had burned down to a certain point. All of the candles were of the same size and marked at the same place. In that way, all the parts of his large army could attack at the same time. It seems to me that I have read of the New England people telling time in this way when candles were used for lighting purposes.

There is another kind of clock that was used as far back as 1600 years ago by both the Romans and the Chinese. You probably have never heard of this kind of clock, so I will tell you about it. Then, perhaps, you may be able to make such a clock.[1] This kind of clock is called a Clepsydra or water-clock. It tells the time by allowing water to trickle through a small hole in one dish floating in another. As the inner dish filled with water it would sink deeper and deeper. The depth to which it had sunk marked the time. Another type allowed

1 From this could be developed a home project.

water to trickle from one dish into another. The amount of water in the second dish would indicate the time. A stick might be floated in the dish with the hours marked on it.

Charles. Oh, I could make one of those.

Teacher. All right, Charles, make one and bring it to school, so that we can all see it. Perhaps several of you would like to try it.[1] Of course, all of these methods are rather inaccurate. It was not until Galileo noted the swinging lamps in a cathedral that we were enabled to make machines to tell time very accurately.

Mary. How did watching some lamps swing help any?

Teacher. I am going to leave that for you to find out for the next lesson. I want you to read about how Galileo watched the swinging lamps and what he learned from them.[2] Perhaps some of you would like to make a clock and bring it to school.

John. I will make a candle clock.

Charles. I'll make a water clock.

Dora. I will bring my sand-glass.

Teacher. That will be fine. Alice, do you notice that the sun shines through that window and casts a shadow on the blackboard? Will you, as often as you can tomorrow, make a chalk mark where the shadow is, and write on this mark the time. Then we will have a sun-dial right here in the room. We will find out about Galileo, and then I will tell you about how the clocks we use today work, and perhaps something about how we know that our clocks are right.

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2 References that may be assigned are: Everyday Mysteries—Abbot—Chap. V—Fixing the Clock; Makers of Science—Hart—Chap. VII—Galileo; Galileo Galilei—Karl von Geber; Galileo, His Life and Work—J. J. Tahie—pp. 9, 26, 396; Encyclopedia—Clock, Watch, Horology.

Another Shortage

Along with the coal, gasoline and nitrate shortages which have been predicted, we now have predicted a bread shortage. The date is set for two centuries hence.

Testing the Results of Science Instruction; Some New Types of Tests

By Herbert Popenoe, Department of Statistics, Los Angeles City Schools.

The following article is a rough draft made from notes prepared for oral presentation at a luncheon talk during the Southern California Conference on Science Teaching, under the auspices of the summer session of the University of California, Southern Branch, and of the Committee on the Place of Sciences in Education, American Association for the Advancement of Science.—Editor.

During the past ten years, continued investigations have revealed marked deficiencies in the old methods of examination and assigning of grades based on teachers' estimates, and there has been a continual demand for a technique of examination that would to a large extent obviate the observed discrepancies and bring about a more reliable system of grading.

Below will be given two reasons why a new type of test is needed, and three suggested remedies for the situation. The investigations of Starch and Elliot at Columbia University have shown that different teachers vary widely in the grade or mark which they assign to a given examination paper. One geometry paper was reproduced photographically and sent out to 116 teachers. These teachers graded the paper on the basis of 100, with a passing grade of 75, and returned the papers to the investigators. The results of the investigation are shown below. The median score assigned was 70, but the range was from 28 to 92, and the middle 50% of the grades varied from 63 to 77.

Distribution of Marks Assigned to one Geometry Paper by 116 Teachers.

Below 50	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85–89	90 or over
6	7	7	17	18	13	23	15	7	3

Median of 70. Passing grade, 75. Range, 28 to 92. Quartile dev., 7.

If the condition is so astounding in such a definite subject as mathematics, what might we not expect in such a subject as English literature, where even the opinions of experts do not agree? It simply means that we cannot expect two teach-teachers to agree as to the mark which should be given to an examination paper under the old system.

Distribution of marks in different departments of a California high school in per cent of the total marks given by the department.

Department	% A's	% B's	% C's	% D's	% E's
Biology	5	65	18	2	10
Commerce	10	70	5	10	5
English	8	60	12	10	10
Home Econ.	20	70	3	0	7
Languages	14	52	14	8	12
Mathematics	7	35	33	10	15
Music	40	45	0	8	7
Phys. Ed.	30	55	11	0	4
Social Sciences	17	40	23	6	14

Without going into the above table too deeply, it might be noted that the Biology department gave a grade of A to 5% of its students, while the Music department gave a grade of A to 40% of its students, while the other departments ranged in between. The Commerce department failed 5% of its students, while the Social Science failed 14%. Home Economics and Physical Education gave no grades of D, while Commerce, English and Mathematics each gave 10% of D grades. All this simply means that there is no more accord between the various departments in relation to the distribution of grades for their students than there is in the case of individual teachers grading a particular examination paper.

It was to improve this situation that the researches were undertaken which have led to the development of the newer type of examination and the standardized test. Now the standardized test is in no ways different from the old type of examination, except that it is better. The old type of examination, called the *thesis* examination, permitted the student to throw dust into the eyes of the professor to evade answering the questions specifically, or on occasion to really misunderstand the question. Also it demanded a great amount of time on the part of the professor or his readers in correcting the papers. The new type of examination provided definite situations to which the pupil must react and makes it possible to evaluate the worth of his reactions in a definite manner.

For the benefit of those who may not be thoroughly familiar with the newer types of tests, some examples are given below.

The completion or the recall type of test.

Vaccination is a protection against (smallpox).

The "lady bug" is a representative of the order (Coleoptera).

The enzyme found in the saliva of the mouth is (ptyalin).

The symbol for mercury is (Hg).

The law stating the relation between the volume of a gas and its pressure is known as (Boyle's law).

This type of test consists of a sentence or paragraph stating certain facts regarding the course in which one or more blanks occur where words have been left out, and the appropriate expression must be supplied by the student. This is one of the best types of the newer tests.

The recognition or multiple response type of test.

The center of our universe is the earth moon sun Jupiter Mars.

Food manufacture in green plants is called respiration transpiration digestion mitosis photosynthesis pasteurization.

A collection of tissues specialized for a definite function is called an organism cell larva organ tissue.

An example of a chemical element is $C0_2$ H_2O protein oxygen air.

The unit of weight in the metric system is the liter ounce meter pound gram cubic centimeter.

This type of test consists of a statement to complete which the student underlines the suitable word from among a number of choices which are given him on the printed page. This makes the pupil's responses specific and makes the scoring easily done.

The true-false test.

Pneumonia is a disease of the brain. True-false

The neucleus plays an important part in heredity. True-false

The circulation of the blood was discovered by Harvey. True-false

Precipitates are always colorless. True-false

Newton formulated the law of gravitation. True-false

The "true-false" type of test consists of a number of statements, some of which are true and some of which are false. The pupil is to identify each statement as to its truth or falsity, and draw a line under the word "true" or under the word "false." This is by far the most rapid of any of the examination forms and makes it possible to cover a great deal of ground in a class period. There have been raised two objections to this test: one, that it permits guessing; two, that it is unwise to present false situations to the pupil. *Statistical investigation shows that the matter of guessing is negligible and does not in any way affect the worth of the test.* (Italics are the editors.) As to the presentation of false statements, this is exactly what we are confronted with in everyday life, and perhaps it will not be amiss to prepare the student to meet the situations of life. When someone says, "The summers are getting hotter year by year," we must decide for ourselves whether this statement is true or false. In fact, we are called upon much more frequently to differentiate between the true and the false than we are to recite memorized knowledge in a pedantic manner.

Perhaps the better types of the new examination will contain all these and other methods in the same test. It is not that we have secured a specific form of phraseology, but that we have learned the necessity of making both the examination situation and the pupil's reactions as definite as possible.

There are five things to look for in evaluating any type of examination. These are validity, reliability, objectivity, ease of administration and scoring, and norms or degree of standardization.

By validity we mean the real worthwhileness of the examination. Does it mention what it purports to mention and what we intend to measure? These questions are best answered by the judgment and opinion of authorities in the particular field.

By reliability is meant the degree to which a test or examination measures what it really does measure, or the extent to which it is precise and accurate. This can be very neatly determined by statistical methods of self correlation.

Objectivity is the degree to which the personal element or judgment is eliminated in the scoring of answers. This is

mostly a matter of the mechanical construction of the examination. The new type of examinations has a decided advantage in the case of administration and scoring. The instructions to the pupils are simple and easily solved, and since the responses are definite and either right or wrong, scoring can be done by clerical workers without previous experience or training. Pupils can be trained for this task, and even where the teacher must do the grading of the paper, the task is economically carried out.

Although norms are more or less essential to standardized educational tests, examinations are primarily measuring instruments. A pupil can be said to have been measured when he has been correctly placed in such a way that his achievement relative to that of other members of the class has been reliably ascertained. Although it is convenient to have norms of national scope for a test, the reputed value of such standards have probably been greatly over-emphasized. All this simply means that a test of the newer type which can be readily constructed by the individual teacher will give practically all the good results to be expected without the question of standards or norms being really involved in any way.

The standardized and objective type of examination is not a panacea for all educational ills, but it will increase the reliability of teachers' marks and greatly improve the extent to which differentiation of pupils' ability is possible.

More Uses for X-Rays

Every day new uses are being found for X-rays. By the use of X-ray spectra the missing chemical elements numbers 43 and 75 in the group with manganese in the periodic table, have been discovered. This now leaves but three vacant places in the periodic system. Also by means of X-ray spectra the inner structure of rubber has been shown. By this means it has been found that when rubber is stretched beyond a certain point it begins to crystalize. These experiments with rubber may throw more light on the size of the rubber molecule, which is now a point under discussion. A French chemist is working on a method by which certain chemical analyses will be greatly speeded up by the use of X-rays.

Food Habits Developed

By Nellie Jaroleman, M. A.,
Lowell Junior High School, Oakland, Cal.

In the low seventh grade General Science course of the Lowell Junior High School at Oakland, California, considerable time is devoted to a study of the growing child. An attempt to develop a desire for forming the proper health habits constitutes the major part of this topic. Generally, the classes select the following habits as the most essential: exercise, sleep, cleaning the teeth, baths, and food. Very often charts are made out for recording data in reference to these daily habits.

Although the daily charts presented quite satisfactory results on the whole, the teacher was quite conscious of the fact that these health habits were not going to become as effective and permanent as desired unless the children really believed in them through some personal observation or experience.

It was decided to experiment with six baby chicks, divided into three groups of two each. The cages were placed side by side and given the same care. The chicks were all from the same hatching and as nearly the same weight as possible. The experiment was conducted for eight weeks. Cage 1 received grain, water, milk and greens; cage 2, grain, water and milk; and cage 3, grain, water and greens. Weights were taken daily. The chickens of cage 1 increased in weight daily and both developed into strong, healthy chickens; the chickens of cage 2 gained weight the slowest of all, one died and the other never attained the size of any of the others; and the chickens of cage 3 gained weight more quickly than those of cage 2, but not as much as those of cage 1; one died and the other was somewhat undersize in comparison with the chickens of cage 1.

The experiment was repeated with white rats, and the results were practically the same.

It was very surprising to discover how much interest was aroused in this way, both among the children and their mothers. Daily charts were no longer used, the experiment had "sold itself," because now the children were using the proper food habits for the reason that they themselves were convinced of the values.

When Galileo Astonished the Venetian Senate

Up to the seventeenth century the heavens were a region of unexplored mystery. The ancients had, indeed, some organized knowledge of astronomy, very remarkable in many ways. But, with nothing to aid the naked eye, the conception of stellar conditions and movements was meager and often erroneous. It was the telescope that opened up the wonders of other worlds.

One of the first successful telescopes was made by Galileo in Venice. This great genius had heard of the accidental discovery of the Dutch optician that two lenses held in a certain position would give better results than one lens. After experimenting for quite a time, Galileo constructed a telescope which he afterwards presented to the Doge of Venice. It consisted of a tube of lead fitted with two lenses of lead glass, which brought into view objects twenty miles away.

This achievement, measured by our present day standards, is not at all striking. In 1609, however, it was something to be marveled at and talked about for days. So great was the curiosity regarding this new invention that the entire Venetian Senate climbed to the top of the highest church in the city to see ships that were yet two hours distant from the harbor.

Although the modern telescope is based upon a different combination of lenses, the lenses themselves are still generally made of lead glass. Lead lends greater refractive power to glass and thus increases the strength of the lens. In addition, lead contributes the qualities of toughness and brilliancy, as well as a lower softening temperature, making the glass easier to work.

In making lead glass, ordinary lead is melted at a high temperature. On cooling, it falls into buff-colored flakes or litharge, a yellowish powder containing one atom of oxygen to every atom of lead. Reburning and recooling the litharge produces red-lead. This is mixed with silica and potash or soda to form clear glass of the finest quality. Lead glass is

also used for microscope lenses and in other instruments where fine lenses are required and where its properties are particularly necessary.

From The Dutch Boy Quarterly,
Published by the National Lead Co., 111 Broadway, N. Y. C.

Reproduction of Galileo's telescope, showing tubes of lead.

Northern California Conference on Science Teaching

Dr. Edna W. Bailey and Mr. Clyde M. Westcott, Pacific Coast members of the Committee on the Place of Science in Education of the A. A. A. S., requested the School of Education in the University of California to conduct two conferences on the problems confronting that committee. One was held in Berkeley, under the auspices of the Summer Session, on July 17 and 18; the other was held at the Southern Branch in Los Angeles on August 3 and 4.

It was planned to make this a small working conference, composed of those who have certain responsibilities with regard to the teaching of science in this state. The plan outlined by Dr. Otis W. Caldwell, chairman of the committee, was used as a basis for the preparation of the program, which follows:

FRIDAY, JULY 17

9.30 A. M.

General Meeting and Organization. *Chairman*—Professor George W. Hunter, Knox College, Galesburg, Illinois.

Discussion—Present situation in science teaching in California. What subjects are taught, where, when, in what year, in what sequence; the training of teachers and the load carried by teachers. *Leader*—Miss Elizabeth Bishop.

2.00 P. M.—Three Section Discussions

The Science Laboratory; planning and equipping. Standard lists. Costs. *Leader*—Mr. Clyde M. Westcott, Head of Science Department, Hollywood High School.

The Synthetic View of Science in Relation to Organization of Courses in High School and College. *Leader*—Dr. Richard Holman, Asst. Prof. of Botany, University of California.

Science and Health: What are the Scientific Fundamentals Essential for Health Education? *Leaders*—Dr. J. N. Force, Prof. of Hygiene, University of California; Dr. Agnes Fay Morgan, Prof. of Household Science, University of California; Dr. Richard Bolt, Asst. Prof. of Hygiene, University of California.

SATURDAY, JULY 18

9.30 A. M.

Discussion—Present Day Problems: Relation of Science Teaching to Religious Education. *Leader*—Dr. Edna W. Bailey, Supervisor of the Teaching of Science, University High School, Oakland. How Shall We Treat the Evolution Theory in Teaching Elementary Biology? *Leader*—Miss Mabel B. Peirson, Head of the Department of Biological Sciences, Pasadena High School.

Luncheon, 12.30 P. M.

Science for the Millions. *Speaker*—Dr. William E. Ritter, President Science Service, Inc. Science in the Secondary Schools. *Speaker*—Dr. Leonard V. Koos, Prof. of Secondary Institutions, University of Minnesota.

Afternoon

Visits to laboratories at University High School.

The date of the conference happened to coincide with the climax of the Scopes' trial, and, in consequence, it received much unexpected and undesired publicity. The conference was well attended and participation in the discussion was general. The following recommendations were unanimously adopted:

"The science teachers of northern California, assembled in this conference, note with interest the following tendencies and needs in the field of science:

The four dominant sciences in the high schools of California are General Science, Biology, Chemistry and Physics. Botany, Zoology and Physiography have been disappearing, and there has been a large increase in General Science and Biology.

There is considerable confusion throughout the state in regard to the desirable sequence of science courses. After considering the tendency in the state and throughout the country, the conference recommends that General Science be offered by the Junior High Schools in the seventh grade and in at least one other year. In the four-year high schools General Science is recommended for the ninth grade. Biology should be given in the tenth grade. It is recommended by the conference that a Life Science be required of all students in the tenth grade. Chemistry and Physics should be offered in the eleventh and twelfth grades. While there seems to be a greater tendency for students to take Chemistry in the eleventh and Physics in the twelfth, there is not sufficient reason to limit choice in the order of these two sciences.

There is great need for a definition by the College Entrance Board of the subject of Physiology as an advanced science for the third or fourth year of High School.

It is recommended that the University offer two elementary courses in each science, one for those who have had High School work in that subject, the other for beginners.

Many teachers are required to teach Science without adequate preparation, and many teachers prepared in Science are required to teach other subjects. From five to fifty per cent of the teachers in the different schools of California teach some science, and forty-seven per cent of the trained science teachers are teaching other subjects in the high school curriculum. The conference urges increased attention on the part

of high school principals to the assignment of teachers to subjects in which they are properly prepared.

General Science and Biology constitute a large part of the science in the high schools of the state. Teachers of these subjects have not had proper training. There is distinct need of help from the University in the form of training in subject matter used in the two courses mentioned. The conference requests the University to provide adequate preparation, such preparation to include courses from the following fields of science: Chemistry, Physics, Botany, Zoology, Biology, Physiology, Bacteriology, Public Health and Nutrition. (There was a general feeling that Earth Science should also be included.)

In order that science teachers might be better able to realize the possibilities of Science in the training of young people to meet the problems of modern life, it is recommended that an extensive and thorough experimental study be made of the science training needed by the individual living in modern society, the selection and organization of subject matter, and the choice of methods to be used in order to realize these desired ends.

It is recommended that the Commissioner of Secondary Education of California provide a clearing-house for laboratory plans, specifications for laboratory furniture, equipment and standard lists of supplies for each of the courses now commonly given in the secondary schools of the state. Also that copies of such material be prepared and made available to all teachers of science who desire them."

Two hundred reels of motion-picture film and 9,400 slides are distributed by the visual instruction service of the University of Oregon. These present historical scenes, classical drama, art, fairy stories, birds and animals, rocks and minerals, fish and plant life, and other subjects. They are widely used by communities and schools throughout the state.

American Council on Education, Division of College and University Personnel

During the academic year just past the Personnel Division of the American Council on Education in Washington, D. C., received 440 calls for teachers. This shows an increase of 300 per cent over the previous year and is only one indication of the rate at which interest and confidence in the enterprise is spreading throughout the college world. It may not be too sanguine to predict that information about a thousand opportunities will come to notice of the Division during the coming year.

The vacancies referred to the Council for filling range in importance from part-time instructorships with opportunities for graduate work to college presidencies. Forty positions paying better than $5,000 were included in the year's list.

The Personnel Division is being conducted on a high professional plane, charging no fees or commissions to registrants. An organization which is thus impartially beneficial to teachers and executives, which operates on a national scale and within a limited budget, can do its best work only as a co-operative enterprise. All college teachers and all graduate students preparing to teach in college are urged to register.

Inasmuch as the bureau is rapidly gaining in importance as a repository for significant and much needed facts about the teachers of the country, all members of the profession are asked to enroll, whether or not they are interested in change. Those who have registered in previous years are requested to send in notice of any change they wish made in their records.

The following statement appears in the current number of the Educational Record: "On the basis of the progress made to date, there is every reason to believe that college men and women, by co-operation through the Personnel Division, can build up and maintain a body of fact about the profession which will bring system and coherence into the placement and interchange of college teachers, will contribute toward a redefinition of their place and prerogatives, and will thus eventually bring them into more harmonious relation with the system within which they must work."

American Men of Science

Dr. John M. Coulter, Head of the Department of Botany of the University of Chicago since the organization of the department, formerly President of Lake Forest University, and preceding that President of Indiana University, eminent botanist, teacher, student, author, editor, and counselor in numerous scientific committees and societies, is discontinuing active headship of the Department of Botany at the University of Chicago at the close of this academic year.

During the present year Dr. Coulter has been assembling material for a proposed volume upon "American Men of Science." This volume is designed for collateral reading by science students in secondary schools and elsewhere. It is being developed in connection with the program of work of the Lincoln School of Teachers College, of whose staff Dr. Coulter will be a member during 1925-26.

During the next year Dr. Coulter will reside in Yonkers, and in addition to the above work in the Lincoln School, he will act also as general adviser in the work of the Boyce Thompson Institute for Plant Research.

Mr. Walter G. Whitman, Director of Science at the Massachusetts State Normal School, at Salem, has a year's leave of absence, which he is spending at Nanking University, China. Mr. Whitman is well known throughout the country as the author of three of the most successful general science texts now in use and as the publisher of THE GENERAL SCIENCE QUARTERLY.

Large telephone companies throughout the country have found that pine poles impregnated with coal-tar creosote give the longest service. Following the advice of the Bureau of Entomology of the United States Department of Agriculture, California electric power lines are using a large number of yellow pine and Douglas fir poles which have been impregnated with coal-tar creosote, instead of untreated red cedar poles, which were badly damaged by termites. These pine poles have been treated for their entire length by the open-cell pressure method, which will prevent bleeding or sweating of the creosote.

The New Books

Plane and Solid Geometry—Schultze, Sevenoak and Schuyler—The Macmillan Co.—480 pages—numerous cuts.

This is a re-written edition of the author's revised book. It has been made to conform to the new requirements of New York State Regents and the College Entrance Examination Board. Additions have been made; some propositions are more fully developed than in previous editions. The plan of "proof" by parallel columns for *statements* and *reasons* is very helpful.

High School Chemistry—Charles E. Dull—577 pages—250 cuts—Henry Holt and Co.

This is a comprehensive chemistry text of college entrance grade, which is not lacking in human interest. It gives the essential facts and theories intermingled with the practical applications. It describes up-to-date use of chemistry. Chapters are followed by summaries and questions.

Personal Hygiene Applied—Second Edition—Jesse F. Williams—414 pages—42 ilustrations—$2.00—W. B. Saunders Co.

Practice of the teachings of this book will do much to accomplish its aim, which is to improve the quality of human life." The chapter headings are: The Meaning of Health; The Health Problem; Intelligence and Ideals; The Approach for Knowledge and Health; Science and Attitudes; Hygiene of Muscular and Skeletal Systems; Hygiene of Nutrition; Hygiene of the Respiratory System; Hygiene of the Circulatory System; Hygiene of the Excretory System; Hygiene of the Nervous System; Hygiene of the Sexual Aspects of Life; Prevention in Specific Diseases; Hygiene of the Mouth, Eye and Ear.

General Science—William H. Snyder—591 pages—wel lillustrated—Allyn and Bacon.

This book treats: the open sky; the universe in motion; matter; nature at work; man's control of heat; heat in the house; heat and the earth's crust; the atmosphere; the waters of the earth; water as the servant of man; weather and climate; rocks and soils; light and its relation to life; plant life; animal life; human life and health; man's devices controlling energy; electricity in modern life. The book is attractive in its appearance, interesting in the reading, and valuable in its content.

Quantitative Analysis—James M. Hendel—137 pages—$1.40—Ginn and Co.

This is a text for a one-year college course in quantitative analysis. The fundamental principles of analytical chemistry are presented with specific illustrative methods. The theory underlying each method is in acocrdance with the modern ionic theory. There is at the end a good chapter on electrolytic methods.

Vertebrate Zoology—Revised edition—H. S. Pratt—341 pages—$2.20—Ginn and Co.

This book is a guide to the dissection of types of important groups of vertebrates. Each of the dissections is complete, so that they may be used in any desired order. The groups represented are: Fishs, Amphibians; Reptiles; Birds; and Mammals.

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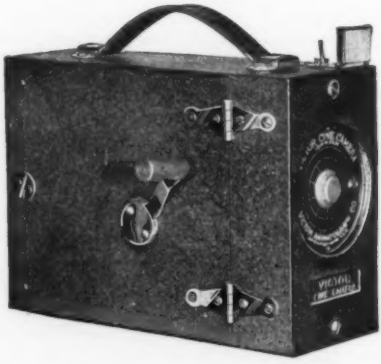

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Open Doors to Science—Caldwell and Meier—333 pages—204 illustrations—96 cents—Ginn and Co.

This is an elementary science text well within the comprehension of 6th and 7th grade children. It treats: Common Problems of Living; Fire and its Uses; Light and its Uses; Fire Control; Water Supply; Household Wastes; Fire in the Preparation of Food; Foods, production, care and requirements; Clothing; Home Grounds and Gardens; Indoor Equipment; Hygiene; Transportation; Communication; Recreational Science. Each chapter opens with a list of stimulating questions, and ends with a good list of "things to do." This is one of the best books we have seen for the beginning science pupil.

Elementary Principles of Physics—Fuller, Brownlee and Baker—883 pages—728 illustrations—Allyn and Bacon.

"The attempt has been made in this book to bring the subject to the student in language that he can readily understand . . . without sacrifice of accuracy or completeness." An innovation of this book is that of giving the mathematical subject of mechanics at the end of the book rather than at the beginning. The very full treatment of practical matters together with its real scientific treament, makes this a book to be strongly recommended.

Historic Instruments for the Advancement of Science—R. T. Gunther—90 pages—85 cents—Oxford University Press, New York City.

This is a *guide* to the historical scientific instruments in Oxford. It describes the collections of astrolabes, sun-dials, surveying instruments, telescopes, microscopes, and many other instruments. The museum at Oxford University probably possesses more ancient instruments than any other in the world. A study of this little volume will be most valuable to one contemplating a visit there.

The Book of Plants—Bertha M. Parker and Henry C. Cowles—252 pages—100 illustrations—88 cents—Houghton, Mifflin and Co.

This is the first book in a series of science readers for Junior High School pupils. Such a series has long been needed and we hope it will be speedily increased. Some of the chapters in this book treat: Plants that Eat Insects; The Oldest of all Living Things; Green Plants; The Century Plant; Roots that Grow up into the Air; Desert Plants; Living Dust; Yeasts, molds, bacteria; Pasteur; Story of the Jack Pines; Trees and Sand Dunes; Forest Fires; Foreign Plants.

The Teaching of Science and the Science Teacher—Brownell and Wade—319 pages—$2.00—The Century Co.

This book, one of the volumes in *The Century Education Series*, deals with the fundamentals of instruction in the classroom and with organizing the text-book work and the class-room lecture around the work of the laboratory, in accordance with the best modern practices. It contains chapters on the preparation of the teacher, on his relation to the community in which he lives and works, and on his opportunities for moral instruction and character building. The book offers detailed discussions of special methods for the several sciences, describes the lay-out and equipment of laboratories, and gives information regarding the purchasing of supplies. Although prepared especially for use as a text book in methods for prospective science teachers and for students in colleges, normal schools, and other teacher-training institutions, the book is so practical and so replete with helpful information and valuable suggestions it should find its way into the library of many professional science teachers in service, who will find it a useful manual.

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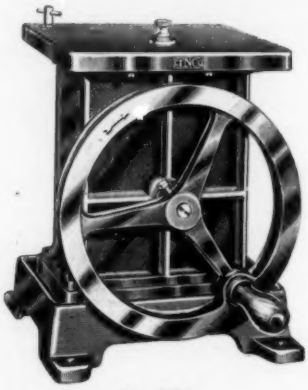

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Junior Mathematics—Book Two—Ernst R. Breslich—263 pages—numerous cuts—The Macmillan Co.

This is the second volume of a series of text books on Junior High School mathematics. Geometry is the basis for the first part of the course. Formulas are developed by actual measurement. Algebraic notation is used to simplify the discussions of some of the geometrical problems. In the second half of the book the emphasis is transferred to algebra and the more abstract meanings of the algebraic notation is developed. The problems are of a practical nature and offer repeated opportunity for arithmetical computation in combination with algebraic and geometric processes.

High Lights of Geography: North America—David Starr Jordan and Katherine Dunlap Cather—358 pages—illustrated with maps and with photographs, including airplane views—$1.44—World Book Company.

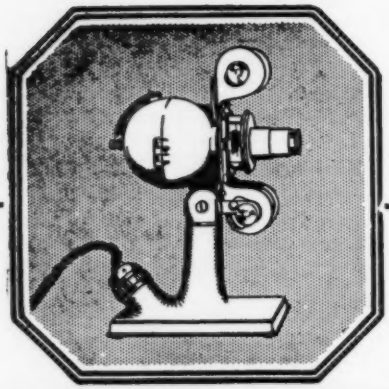
This is a new kind of geographical reader that furnishes fascinating material which courses in geography have sadly lacked. The important physical features, the marvels of nature which the child in the upper grammar grades studies about in his textbook, were not always just as they are now. There are interesting stories, wondrous true tales of the forces of nature at work, that explain these features. It is these vivid accounts of origin and change, of why things are in the world as they are, that are contained in this volume of High Lights of Geography. The authors have set out to make children see and understand the everyday things around them—the river beds, boulders, strata on the hillside. In narative form they treat graphically of mountains, rivers, lakes, of the mineral treasures in the earth, and of life upon the earth. The book supplies that descriptive setting which makes real the forces that have governed man's advance. It is the kind of material that is crowded out of the regular text book for lack of space, but that explains the basis of geography. High Lights of Geography will do more than motivate the study by injecting new interests. By rounding out the subject matter of the textbook, it will give the teacher needed fresh material to build up a clear explanation of commercial and industrial growth, and it will give the child a broad conception of the great principles of geography which no catalog of facts can give him.

Great Rivers of the World—W. S. Dakin—204 pages—illustrated—The Macmillan Co.

A splendid book to acquaint pupils with the geographic influences of the great rivers of the world. It treats of the Niles; the Ganges; the Tigris and Euphrates; the Amazon; the Mississippi; the Yangtze-Kiang; the Columbia; the St. Lawrence; the Rhine; the Rhone; the Danube; Arctic rivers, and River types. The story of each river is interestingly told and the book serves as an excellent type of geographical reader.

The Spectroscopy of X-Rays—Manne Siegbahn—trans. by George A. Lindsay—287 pages—Oxford University Press, New York City.—$6.00.

This is a highly technical book. The first chapter is a summary of the knowledge of X-Rays up to Laue's discovery. The first part of the book gives a description of the technique and experimental methods such as to enable other experimenters to follow out the work. In the second part of the book the significance for atomic physics of the results of X-Ray research is discussed.



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Elementary and Intermediate Algebra—Schultze and Breckenridge—450 pages—(Elementary Algebra is published separately—331 pages)—Macmillan.

This is a revision of the former textbook. The subject matter has been modified to conform with the Report of the National Committee on Mathematical Requirements, and the New York Regents and College Entrance Board requirements. The material has been divided ino two main sections: the Elementary, covering the work of the first year, and the Intermediate, covering a further half year. A new method of approach is used in utilizing some features of the project method. Some new devices for improved teaching have been added. In the "intermediate" section the work on Logarithms has been revised and rewritten, the application of the Binomial Theorem has been extended to include additional applications to compound interest, and a chapter on the use of logarithms in the solution of the right triangle has been added.

Everyday Problems in Science—Pieper and Beauchamp—573 pages—508 cuts—Scott, Foresman and Co.

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Preparation and Use of New-Type Examinations—Donald G. Paterson—87 pages—60 cents—World Book Co.

This book is designed to enable classroom teachers to make up and use new-type examinations in place of the old essay type for weekly tests or final examinations. Such new-type examinations make use of recent progress in methods of test making. While they are not standardized, they do embody the brevity, simplicity and objectivity of the standardized test.

Beginners' Geometry—Smith—324 pages—556 figures—Macmillan.

The keynote of this text is given in a slogan on its title page: "Geometry understood, not memorized." The course is built, not on the organization of the subject matter, but upon the point of view of the pupil. The opening chapter contains several paragraphs of interesting reading intended to give the pupil some of the fundamental ideas of geometry before he reaches them formally. This text makes great use of the original exercise in developing the thought. "The pupil is not shown how to do a thing and then asked to reproduce it. He works out his ideas himself by means of original exercises so carefully graded that he is able to do each succeeding exercise because he has done the preceding one." The work to be done by the pupil is classified into problems, development exercises, proficiency exercises, and miscellaneous exercises.

A Textbook of Modern Physics—Weld and Palmer—737 pages—499 cuts—$3.75—P. Blakiston's Son.

The authors of this text believe that the high school student entering college has not a sufficient knowledge of fundamentals. To quote from the preface of this book: "On the other hand, the meagerness and superficiality of their knowledge of what has been regarded as fundamental in education are often discouraging in the extreme." Perhaps it is because of this thought in the minds of the authors that the material in the text is treated more fully and more technically than has been the trend in the majority of the newer physics texts. Quoting one more paragraph from the authors' preface: "The aim of this textbook is not to popularize physics in the sense of cheapening its content. It is, rather, to present the essentials in a thoroughly modern, scientific manner, but in such language that the student can understand them himself by reading the assigned lesson; thus leaving the classroom period largely free for experimental demonstrations, supplementary lectures and quizzes." It is the opinion of the reviewer that this text would be rather difficult for the majority of high school students, and that the method of presentation of the subject matter is more suited to college than to high school methods of teaching.

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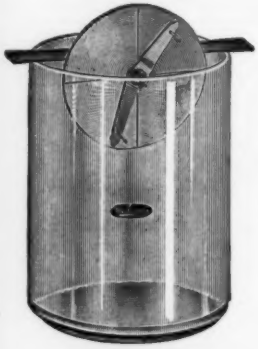

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Science Articles in Current Periodicals

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AIR, COMPRESSED

Where Half an Hour is a Day's Work. Pop. Sci. Mo., p. 35, Sept. 1925.

The Wonders of Compressed Air. Amer. Mag., p. 38, Sept. 1925.

ALCOHOL

The Chemical, Alcohol. Sci. Mo., p. 249, Sept. 19p5.

The Decreasing Use of Alcohol. Lit. Dig., p. 25, July 4, 1925.

BAKING

*The Chemist Enters a New Industry. Ind. & Chem. Eng., p. 449, May, 1925.

CHEMISTRY

Everyday Chemistry. Sci. & Inv., p. 429, Sept. 1925.

Growth of Chemistry in Industry. Jour. of Chem. Educ., p. 640, Aug. 1925.

*The Manufacture of Sulphuric Acid. Sch. Sci. Rev., p. 238, June, 1925.

See also articles listed under "Leather" and "Baking."

EARTH

What the Earth is Made of. Lit. Dig., p. 21, July 18, 1925.

EARTHQUAKES

Cracks in the Earth Menace Big American Cities. Pop. Sci. Mo., p. 21, Sept. 1925.

ELECTRONS

Crash of Electrons Heard. Pop. Sci. Mo., p. 56, Fem. 1925.

EXPLOSIVES

The Taming of Dynamite. Pop. Sci. Mo., p. 33, Apr. 1925.

FERTILIZERS

Fertilizers from the Air. Sci. Mo., p. 245, Sept. 1925.

FOOD

The "Air Giant" on the Dinner Table. Lit. Dig., p. 21, July 11, 1925.

Foods Discovered with America. Sci. Mo., p. 187, Aug. 1925.

Mushrooms—How to Tell Whether They are Edible or Poisonous. Nat. Health Mag., p. 542, Aug. 15, 1925.

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Radio Talks on Science—Coal. Sci. Mo., p. 171, Aug. 1925.

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GLASS

Shall We Live in Glass Houses? Lit. Dig., p. 23, May 9, 1925.

GRAVITY

How Gravity Acts. What is Gravitation? Sci. & Inv., p. 223, July 14, 1925.

HEALTH

Our Unseen Foes in the Air. Pop. Sci. Mo., p. 27, Oct. 1925.
The Magic Stuff that Saved Nome. Pop. Sci. Mo., p. 27, Apr. 1925.
The Conquest of Typhoid Fever. Amer. City, p. 291, Sept. 1925.
Malaria. Hygeia, p. 437, Aug. 1925.
Sewage Treatment. The Edison Monthly, p. 207, Sept. 1925.
Some Sewage Disposal Problems Discussed. Amer. City, p. 266, Sept. 1925.

HEAT

*Doctor Maclean and the Doctrine of Phlogiston. Jour. of Chem. Educ., p. 743.

HISTORICAL

From Jungle Pit to Modern Blast Furnace. Pop. Sci. Mo., p. 55, Mar. 1925.
Ancient Steam Generators. Sci. and Inv., p. 405, Sept. 1925.
Lifting the White Man's Burdens when the World was Young. Ind. Dig., p. 274, Apr. 1925.
*Chemistry and Science in Prehistoric America. Jour. Chem. Educ., p. 589, July, 1925.
Mastodons on Manhattan Lit. Dig., p. 25, May 9, 1925.

ILLUMINATION

How to Shade Your Eyes. Pop. Mech., p. 371, Sept. 1925.

INSECTS

Insect Musicians. Lit. Dig., p. 21, Oct. 3, 1925.

INVENTIONS

The Passing of Uncle Sam's Old Curiosity Shop. Mentor, p. 3, Sept. 1925.
The Story of the Typewriter. Mentor, p. 15, Sept. 1925.

LEATHER

Shoe Leather from the Shark. Pop. Sci. Mo., p. 43, Sept. 1925.
Chemistry and the Leather Industry. Jour. Chem. Educ., p. 363, June, 1925.

LIGHTNING

Where Lightning Strikes Twice. Pop. Mech., p. 403, Sept. 1925.
Why Lightning is Dangerous. Lit. Dig., p. 24, May 9, 1925.

MACMILLAN EXPEDITION

Scientific Aspects of the MacMillan Arctic Expedition. Nat. Geog. Sept. 1920.

MATTER

*Matter—Is There Anything in It? Ind. and Chem. Eng., p. 885, Sept. 1925.
Is Matter Indestructible? Lit. Dig., p. 19, Aug. 29, 1925.

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Old Probabilities—for Years He has Forecast Rain or Shine. Mentor, p. 51, Sept. 1925.

The Thunderstorm. Sci. Mo., p. 253, Sept. 1925

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